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BULLETIN OF THE TORREY BOTANICAL CLUB
VOL. 86, NO. 5, PP. 283–289 SEPTEMBER, 1959

THE POLLEN CULTURES OF C. D. LARUE: A TISSUE FROM THE POLLEN OF TAXUS

WALTER TULECKE

The curiosity which led Carl D. LaRue to search for unusual responses among plants was a constant stimulus to his students and colleagues. His field was that of plant morphogenesis; he was interested in influencing the form of plants and thereby gaining an understanding of their functions. He worked both in the field and in the laboratory and was one of the early investigators to make use of *in vitro* techniques. LaRue experimented with the regeneration of plant embryos (1936); the culture of flowers *in vitro* (1942); the growth of an endosperm tissue from corn (1949); and the culture of gametophytic tissues, especially those of gymnosperms (1953). One of his desires was to obtain a tissue from cultures of germinated pollen, either angiosperm or gymnosperm. In this he succeeded, yet he was kept from completing and publishing this work by his untimely death in August, 1955.

This paper is concerned with the pollen tissue which "C. D." (as he was known to his friends) obtained from *Taxus;* it also presents some of his other work with pollen cultures.

Experimental results. LaRue placed in culture the pollens of a great number of plants which were available at the Botanical Garden of the University of Michigan, as well as other species which were native to Michigan; he also made notes on the percentage germination, optimal sucrose concentration, and the various media used. The genera which he cultured include *Catalpa, Digitalis, Guava, Asclepias* (4 species) *Crinum, Vinca, Chicorium, Physalis, Daucus, Hemerocallis, Hypericum, Oenothera, Gloxinia, Stapelia, Hibiscus, Campsis, Ipomoea, Hoya, Claytonia, Ceropegia, Erythronium, Mirabilis, Zea, Gesneria, Viburnum, Erythrina, Diospyros, Saponaria, Passiflora, Tradescantia, Apocynum, Verbena,* and *Petunia.* In none of these, however, did he record observations of cell divisions or tissue formation although he earnestly sought to obtain a tissue culture from an angiosperm pollen.

Among the gymnosperm pollens cultured and observed by LaRue were those of *Ceratozamia mexicana, Zamia floridana, Dioon, Taxus cuspidata, Taxus baccata, Taxus brevifolia, Podocarpus macrophylla, Cedrus, Picea, Pinus sylvestris, Pinus mugho, Cryptomeria, Cupressus, Chamaecyparis, Juniperus monosperma, Juniperus chinensis* var. *Pfizeriana,* and *Ephedra.*

Included in LaRue's notes is an interesting observation that during germination certain pollens possessed an outer gelatinous coat which swelled

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when the pollen was moistened. This coat ruptured and frequently was cast off during germination; LaRue observed this in *Juniperus, Cryptomeria, Chamaecyparis, Cupressus,* and *Taxus.* Of some pollens, such as that of *Chamaecyparis,* when grown on White's medium (1943) with added indolacetic acid (1 ppm), he wrote that he observed, "everything from undisturbed pollen grains up to tubes, one with 4 or 5 branches and up to 4 nuclei." But this type of response was exceptional and was observed only in gymnosperm pollen.

It was the Taxus pollen, however, which showed the most abnormalities in culture, and it eventually formed a tissue, despite LaRue's earlier statement (1954, 202), "In *Taxus* no tendency to form a continuing tissue

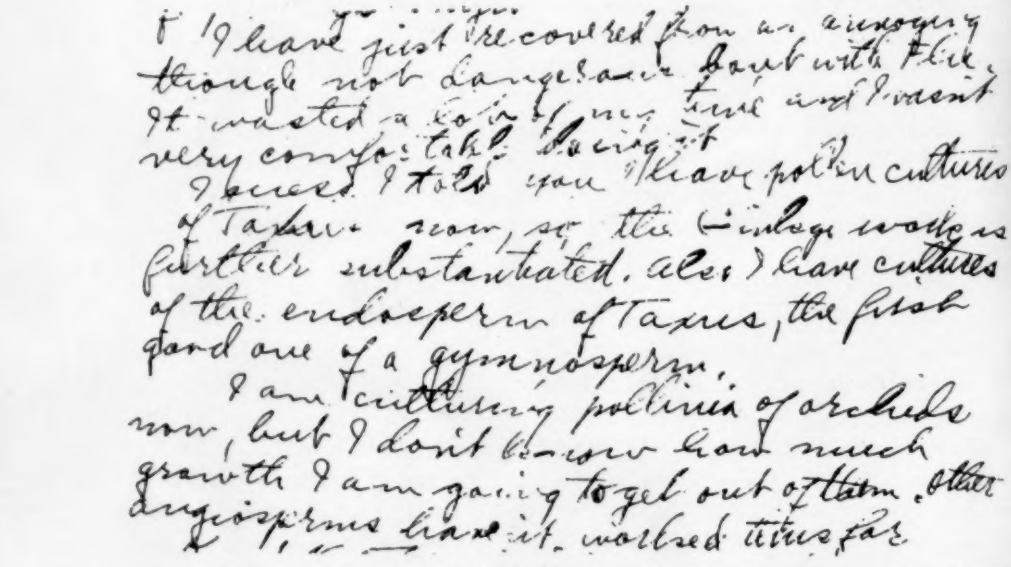

FIG. 1. Excerpt from a letter, dated March 8, 1955, from C. D. LaRue to the author.

has been found, except for the addition in cell numbers and the production of perhaps as many as four times, or even more, the normal number of nuclei." LaRue composed this statement in the spring of 1953. The following spring, 1954, Joseph Krakow, a graduate research assistant in LaRue's laboratory, wrote, "I think we've finally got a tissue from *Taxus* pollen—as yet it's still growing slowly though." In March, 1955, a letter from LaRue to the author (fig. 1) confirmed the origin of the tissue as being from *Taxus.* The species is probably *T. brevifolia,* since this pollen was cultured and observed more than the other pollens.

The tissue culture from *Taxus* pollen is a white tissue mass made up primarily of elongated cells which intertwine to form a dense tissue. These long cells grow in such a manner as to form mounds of relatively hard

tissue on the surface of the nutrient medium (fig. 2). The periphery of the culture gives the appearance of a pincushion with many of the cells sticking out at right angles to the surface of the tissue. The elongated cells, the dominant type, are shown in figure 3. In their growth they resemble pollen tubes and have their nucleus and most of the cytoplasm localized at the tip of the cell. When division of such a cell occurs, the nucleus divides and one daughter nucleus remains in the elongated cell while the other nucleus and most of the cytoplasm are walled off in a small cell at the end of the long cell (fig. 4). The small cell then elongates and undergoes a similar

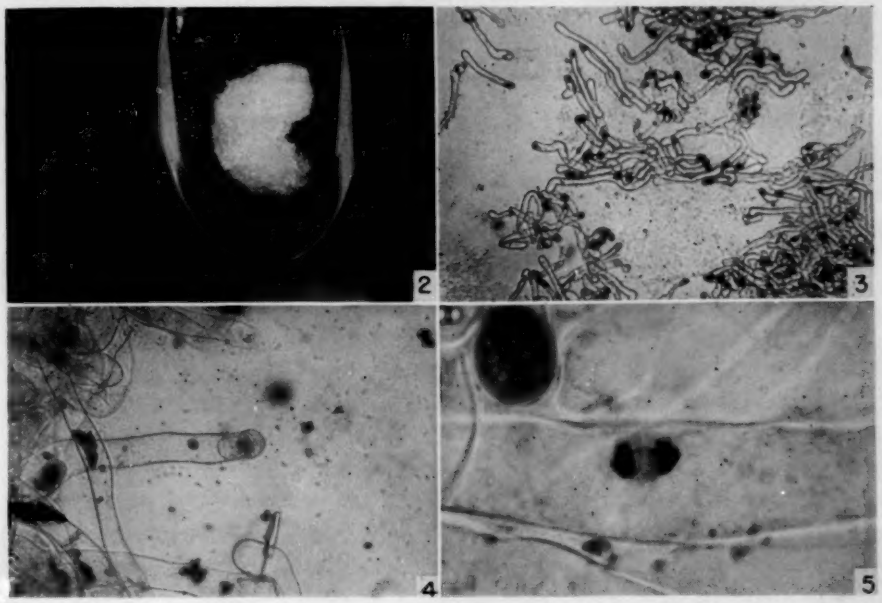

Fig. 2. The tissue culture from *Taxus* pollen. The tissue is dense, white and composed of intertwined elongated cells and some clusters of small round cells. 2×. FIG. 3. The elongated "pollen tube" type of cells of the tissue. This preparation has been stained with acetocarmine to show the dense cytoplasm and nucleus located at the end of these cells. 50×. FIG. 4. An elongated cell after nuclear division: note that most of the cytoplasm is incorporated in the end cell. 200×.

FIG. 5. A telophase stage of nuclear division showing a chromosome bridge. 800×.

division. Another type of proliferation consists of compact groups of cells with large dense nuclei; these grow and divide, but usually do not elongate. Beyond these two cell types, the tissue shows no differentiation into functional cells. The chromosome number has not been determined, but there is evidence of polyploidy and some chromosome bridges have been observed (fig. 5).

As originally cultured, the tissue was grown on a medium, W-2,4-D-CM, containing White's (1943) medium, 2,4-dichlorophenoxyacetic acid (0.6

ppm) and coconut milk (15%). Subculturing the tissue on this medium allowed continued growth. In addition, it was found that a synthetic medium also supported good growth of the tissue. The synthetic medium contained l-arginine HCl (100 ppm), relatively high phosphorus ($NaH_2PO_4 \cdot H_2O$ (150 ppm)), naphthaleneacetic acid (0.1 ppm) as well as calcium pantothenate (1.0 ppm) and the normal constituents of White's medium (1943). This is the same medium which permitted the growth of a tissue from the pollen of *Ginkgo* (Tulecke, 1959).

A comparison of the growth of the *Taxus* tissue on the W-2,4-D-CM and synthetic media is shown in figure 6. Growth is slightly better on the medium with coconut milk than on the synthetic medium, but even the best

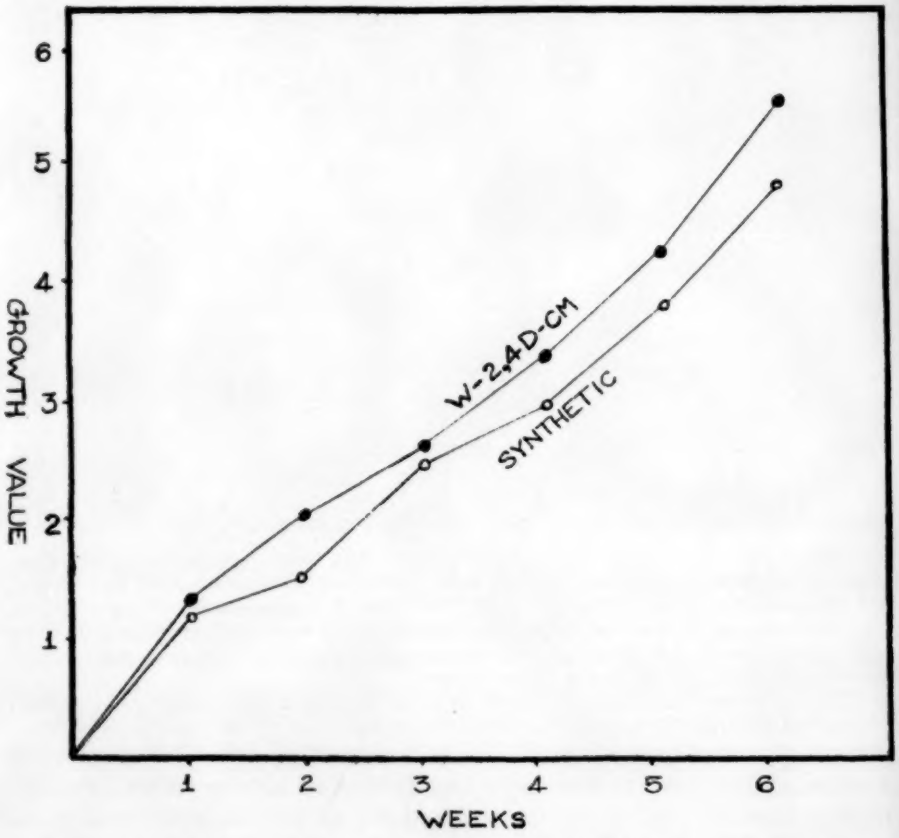

FIG. 6. Growth of the *Taxus* tissue on a medium containing coconut milk and on a synthetic medium. *W*, White's medium (1943); *2,4-D*, 0.6 ppm 2,4-dichlorophenoxyacetic acid; *CM*, coconut milk (15%); *Synthetic*, medium containing White's (1943) plus calcium pantothenate (1.0 ppm), naphthaleneacetic acid (0.1 ppm), 1-arginine HCl (100 ppm), NaH_2PO_4 (150 ppm). The growth value equals the final fresh weight/initial fresh weight.

rate of growth is comparatively slow. Only three times the original weight was attained after four weeks in culture. This rate is somewhat accelerated by using liquid media and agitation, under which conditions the cells are more dispersed, but the growth rate remains characteristically low.

A few attempts were made to obtain new tissue cultures from the pollen of the Japanese yew, *Taxus baccata*. The pollen was cultured by placing surface-sterilized sporangia on several different nutrient media, including the coconut milk medium used by LaRue and the synthetic medium containing arginine. Stored pollen (Tulecke 1954), in the form of a powder, was also tried. The pollen germinated readily, formed long pollen tubes, and underwent some cell divisions. However, no proliferating masses of tissue were formed.

The growth response of the *Taxus* pollen tissue to adenine was tested by making additions to the synthetic medium at 0, 10, 25, 50, and 100 ppm. The growth value (final wet weight/initial wet weight) was less than the synthetic medium with no adenine (control) in each case: control growth value 2.6, adenine, 10 ppm, 1.6; 25 ppm, 1.6; 50 ppm, 1.3; 100 ppm, −1.0. These values were taken after 3 weeks growth in diffuse light at 26° C. These results indicate that the addition of adenine to the medium depresses the growth of the tissue.

The tissue was also inhibited by gibberellin added to the W-2,4-D-CM medium. The gibberellin was added after autoclaving the medium and before the agar solidified. The growth values after six weeks growth (average of two experiments) were: control, 7.2; gibberellin, 1 ppm, 7.0; 10 ppm, 5.5; 100 ppm, 4.0.

A surprising development from this tissue was the selection of a green mutant strain from the original white tissue. The green mutant was formed in sectors of the tissue grown in diffuse light; these were picked and subcultured. Furthermore, this green mutant is distinct from the white strain in growth habit and cell type. The green strain is a loose, easily friable tissue and is composed of cells of the small, round and compact type. It lacks the long filamentous cell type predominant in the original white strain. The growth rate of the green strain is slightly faster than the parent tissue culture.

Discussion. The use of pollen as a source material for unique types of plant tissue cultures has been demonstrated by the growth of tissues from the pollen of *Taxus* by LaRue and the pollen of *Ginkgo* (Tulecke 1953). LaRue attempted to get tissues from other gymnosperm pollens and from many angiosperm pollens as well. Despite his lack of success with angiosperm pollens, he held little doubt that they eventually will be made to produce tissues under the proper conditions of culture.

Aside from their novelty as unusual cultures, these pollen tissues are

important for physiological reasons. If they represent extensions of the vegetative tissue of the male gametophyte, as LaRue believed, then they might contribute to an understanding of the physiology of pollen. Or, if they are quite different from the pollen in their metabolism, then they may aid our understanding of the physiology of the whole plant. The latter is suggested by the work with *Ginkgo* (Tulecke 1959), which shows that strains of tissue with rather specific nutrient requirements may be obtained from the pollen cultured on synthetic media. A tissue requiring arginine has been grown in this way. Such an approach could lead to the selection of strains with particular nutrilite requirements or metabolic products. The fact that pollen tissues are haploid at the time of origin theoretically makes them more limited in their physiological capacity than diploid tissues of the same plant. At the same time, their variable genetic constitution makes them ideal subjects for experiments which are designed to obtain tissues with unusual metabolic traits. Such strains would be similar to the biochemical mutants obtained from many microbes.

The growth of the white strain of pollen tissue of *Taxus* is similar to the slow growth observed in the pollen tubes of many gymnosperms. Attempts to stimulate growth with gibberellin or with adenine, led to an inhibition of growth. By contrast, the pollen tissue of *Ginkgo* responds to both gibberellin and adenine, and grows eight to ten times as fast. This suggests that the slow growth of the *Taxus* tissue may be a true characteristic, rather than a rate of growth limited by the concentration of required nutrilites or by possible toxic components of the medium. Thus, the *Taxus* tissue is distinct in its restraint of growth and differs from the *Ginkgo* tissue in its appearance, cell types, and manner of growth.

SUMMARY

1. As a tribute to the botanical work of Carl D. LaRue, this article cites his success in obtaining a tissue culture from the pollen of *Taxus*.

2. The *Taxus* tissue is dense, white, and undifferentiated, and consists mainly of elongated "pollen tube" type cells.

3. The white tissue has given rise to a strain which is green and consists of small round cells. The green strain is friable and lacks the elongate type of cell typical of the white tissue.

4. Both strains of tissue will grow on a synthetic medium, but the rate of growth is slow.

PHYTOCHEMICAL LABORATORY, CHAS. PFIZER AND CO., INC.
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EFFECTS OF RESPIRATORY INHIBITORS UPON NECTAR SECRETION IN ANTIRRHINUM

HARRY DARROW BROWN

Isolated floating nectaries do not secrete sugar in concentrations exceeding that of the medium. Nevertheless, considering the extremely high concentrations of sugars commonly accumulated by flowers it is difficult to accept the suggestion, frequent in the literature after Liebig (1846), that these glands play only a passive role in an 'excretion' of excess plant carbohydrate. Recent work, (Frey-Wyssling, Zimmerman & Maurizio, 1954) demonstrating that sugar transformations occur in isolated nectaries, lends strong support to the idea that nectaries are active secretory glands employing metabolic energy to accomplish the sugar secretion.

Theoretically, if the nectary uses metabolic energy in the secretion then the presence in the medium of a substance having an inhibitory effect upon the phases of respiration involved in the transport might be expected to affect the secretion of sugar. This is the thesis upon which the present study was undertaken.

Although the analysis of metabolic activity by the effect of known inhibitors has relatively recently gained the status of a coherent technique, a substantial body of literature exists. James (1953) has provided a catalogue of substances known to have activity in plants. The agents chosen for this present study provide a spectrum of the known inhibitors.

Materials and methods. Snapdragons, *Antirrhinum majus* L., var. Candlelight, a tetraploid, were purchased as small plants from a commercial supplier and grown in pots and outdoor beds. Buds were cut from the spike at the stage at which nectar secretion normally begins (Shuel 1956). Bases of the sepals of each bud were carefully coated with a low-melting-point paraffin. The buds were mounted on lucite plates with the floral stalks protruding through holes drilled in the plates. Additional paraffin was used as a seal so that only the floral stalk itself would be in contact with the test solution. After cutting the tip of the stalk, the lucite mount was floated, in a culture dish, upon the test solution. The culture dishes containing the floating, mounted buds were then placed into a covered aquarium tank, the bottom of which contained about a quarter-inch of water.

After approximately 72 hours, the flowers reached full size. The upper parts of the flowers were cut away and the remaining portions were placed, inverted, into the bowl of a Bauer-Schenck sedimentation tube. Nectar was removed by centrifugation. An International Model DU centrifuge was used to exert a force of 465g. for six minutes, after the method of Swanson and

Shuel (1950). Nectar was removed from the capillary well of the tube with a long hypodermic syringe and the concentration, read as sucrose, on a Bausch and Lomb Model 3L refractometer.

Glass- and plastic-ware were soaked, and the buds shaken in a 1:4000 Zephiran chloride solution as a deterrent to the growth of microorganisms. Solutions were buffered at pH6.

Nectar secretion is strongly influenced by humidity (Park 1929). Hence, in these tests the buds were kept in chambers with the air at near-saturation. There did exist, however, a variation in relative humidity since temperature was not accurately controlled. This necessitated reading results in each test run against control buds in the same run.

Test solutions, in the preliminary survey, consisted of 20 percent sucrose and .1 percent of compounds reported to be active as respiratory inhibitors. The agents used were: acetaldehyde, ethyl carbamate, hydroxylamine hydrochloride, iodacetic acid, malachite green hydrochloride, malonic acid, sodium arsenite, sodium azide, sodium fluoride, p-nitrophenol, n-octyl alcohol, pyruvic acid. Sodium chloride was also used at .1 and 1 percent concentrations.

Three of the substances: pyruvic acid, ethyl carbamate, and sodium azide, were selected for additional tests under the condition of varying concentration.

Results. When present in the test solution in concentration of .1 percent, ethyl carbamate, malachite green hydrochloride, sodium azide, sodium fluoride, p-nitrophenol, and pyruvic acid inhibited the production of nectar. That is, the average concentration of nectar in control flowers was more than 1 percent greater than the concentration in experimental flowers. Buds subjected to sodium fluoride and sodium azide did not develop normally. They were markedly stunted, showing only slight growth.

At this same concentration (.1 percent) acetaldehyde, hydroxylamine hydrochloride, iodacetic acid, malonic acid, sodium arsenite, sodium chloride (also at 1 percent), and n-octyl alcohol did not show an effect upon nectar concentration as compared with the control. None-the-less, some of these substances did markedly affect the development of the buds. In the presence of .1 n-octyl alcohol the flowers, after 72 hours, were slightly smaller than normal; those in .1 sodium arsenite and .1 iodacetic acid were stunted and malformed. These data are presented in Table 1.

Pyruvic acid, ethyl carbamate, and sodium azide were employed in series of graded concentrations. Pyruvic acid resulted in the lowest concentration of nectar, hence, highest degree of inhibitory activity of nectar production, when present in the test solution in .5 percent. At both lower and higher concentration the nectar-inhibiting activity of pyruvic acid was less than at this concentration. However, apparent lessening of inhibition

TABLE 1. *Nectar concentration and visible effects upon flowers floated upon solutions containing .1 percent of test compounds.*

Compound	Inhibition of nectar*	Visible effects after 72 hours
Acetaldehyde		
Ethyl carbamate	+	
Hydroxylamine hydrochloride		
Iodacetic acid		malformed, though nearly normal in size
Malachite green hydrochloride	+	
Malonic acid		
Sodium arsenite		stunted and malformed
Sodium azide	+	markedly stunted
Sodium fluoride	+	" "
p-Nitrophenol	+	
n-Octyl alcohol		buds slightly smaller than normal
Pyruvic acid	+	

* Indicated by sugar concentration more than 1 percent lower than that of control buds.

at the higher concentration may not reflect an actual increase in sugar production. For although nectar concentration appeared independent of volume throughout these tests, in the readings for 1.2 percent pyruvic acid volume was approximately half the average of the entire run. Pyruvic acid at .05, .1, .25, .5 percents, although affecting nectar production, had no visible effect upon the buds; at 1.2 percent, however, the highest concentration used, the flowers were noticeably malformed and somewhat smaller than the control flowers.

Similar activity of ethyl carbamate was observed. Here, however, peak activity, indicated by the lowest nectar concentration, was exhibited at .25 percent ethyl carbamate in the test solution. A 1 percent solution of this

TABLE 2. *Nectar concentration, compared with control, of flowers developed upon solutions containing pyruvic acid, ethyl carbamate, or sodium azide.*

Compound	Concentration	Percent concentration of nectar below that of control
Pyruvic acid	.05	0
	.1	1.40
	.25	2.80
	.5	3.60
	1.2	3.10 (growth inhibited)
Ethyl carbamate	.05	.90
	.1	1.92
	.25	2.35
	.5	1.80
	1.0	1.90
Sodium azide	.025	.50 (slightly stunted)
	.05	6.01 (severely stunted)
	.25	8.83 " "
	1.25	9.33 " "

substance, the highest concentration used, had no visible effect upon the development of the flowers.

Sodium azide, in extremely low concentration (.025 percent) visibly inhibited growth of buds, and at higher concentrations completely prevented development of the flowers. Inhibition of nectar production, measurable at .025 percent, became marked at .05 percent. The peak, reached at about .25 percent remained level to the highest concentration tested, 1.25 percent.

Relationships of nectar concentration to the presence of various concentrations of pyruvic acid, ethyl carbamate, and sodium azide are put forward in Table 2. These data are represented graphically in figure 1.

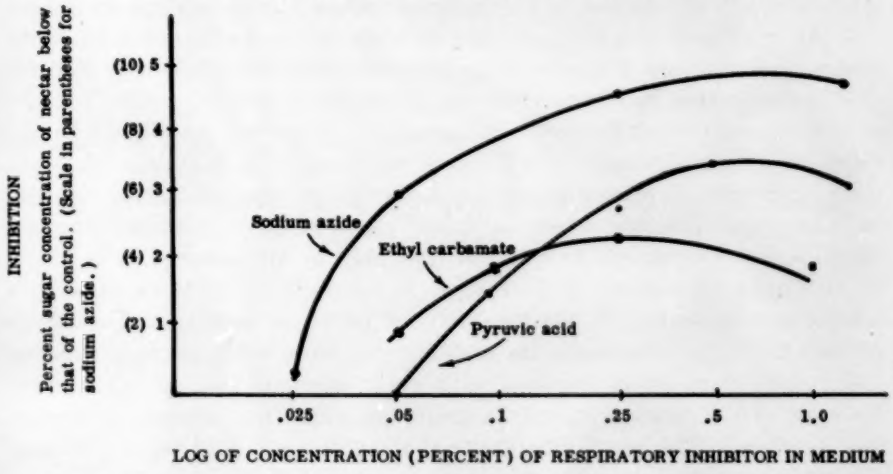

FIG. 1. The relationship of sugar concentration in the nectar to inhibitor concentration in the medium.

Discussion. These data suggest that nectar-secretion inhibition is accomplished by several types of activity. While substances having other types of activity, though they may exert profound effect upon the development of the bud, were without effect upon sugar secretion. Some of the narcotics, malachite green and ethyl carbamate, were effective. Sodium azide, reported to interfere with phosphate transfers (James 1953), did reduce nectar secretion though its effect was generalized as well. Inhibition was also noted for p-nitrophenol which has been related to the cytochrome system by Waygood (1950).

Other metabolic routes, presumably having a place in the physiology of these cells, seemingly are either not involved in nectar secretion or their rôles can be played by other actors in the cell's company. The structural inhibitors: acetaldehyde, reported to be a carboxylase poison by James and James (1940); and malonic acid, succinic dehydrogenase inhibition reported

by Quastel and Wooldridge (1928), did not inhibit sugar secretion. Hydroxylamine hydrochloride, said to inhibit enzymes possessing essential carbonyl groups (James 1953) and the alkylating reagent, iodacetic acid are both inactive at the concentration used. This would seem to indicate that nectar secretion does not, essentially, involve enzymes which critically contain either carbonyl or sulfhydryl groupings.

There are several reports of reactions being inhibited by normal end-products. Green and Brosteaux (1936) found that pyruvic acid functioned in this way upon lactic dehydrogenase. The curve of activity given above would indicate that the inhibition was of a competitive nature.

Curves for both ethyl carbamate and pyruvic acid show a decrease in inhibition, i.e., an increase in sugar concentration after a peak of inhibition. For the pyruvic acid a sharp decline in nectar volume was noted when the respiratory inhibitor was present in high concentration. This may indicate that the reduction in volume of nectar is related to a more general toxicity at this concentration. No such correspondence to volume was shown by the data for ethyl carbamate though here the decline in inhibition was not marked. If the declines pictured in these curves represent actual decline in inhibition then we might suppose, conjecturally, that an alternate physiological system can be brought into play by the plant.

It would, of course, be premature to attempt to fit these data to a scheme in explanation of the biochemistry of nectar secretion. The effects of anti-metabolic substances do undoubtedly vary with varying material and results must be interpreted with great caution. Too, in this survey, for most of the substances, only a single concentration, arbitrarily chosen, was employed. The possibility exists that substances inactive at this concentration might show activity at other concentrations.

The important observation upon which these data are insistent is that nectar secretion is a function of the metabolism of the nectary itself and that the relationships are subject to investigation through the use of respiratory inhibitors.

SUMMARY

1. Nectar secretion by snapdragon buds floated upon a sugar medium was inhibited by the presence in the medium of substances of known anti-metabolic activity. Other agents, though some had definite effects upon bud development, did not affect nectar secretion.

2. Three compounds, pyruvic acid, ethyl carbamate, and sodium azide, were found to inhibit sugar concentration of the nectar with a correspondence to their concentration in the medium.

3. These data support the thesis that nectar secretion in isolated flowers is a function of the active metabolism of the nectary.

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A PRELIMINARY ESTIMATE OF THE IMPORTANCE OF HYBRIDIZATION IN SPECIATION[1]

IRVING W. KNOBLOCH

There seems to be general agreement regarding the presence of hybrids in nature and that hybridization is a speciation process. At this point, agreement apparently stops. In this paper, the term "hybrid" is used to indicate the offspring of a cross between two recognized species in the same genus or between species which are in different genera or higher categories. The term "speciation," as used here, refers to the formation of new or hitherto unknown species by any means.

One apparently logical method of scrutinizing the phenomenon of speciation is as follows: the variation exhibited by species is basically hereditary in nature and species are hereditarily different. As is well known, environmentally-induced variation is of no consequence in speciation. The diagnostic difference between species can be caused by four different mechanisms. These are: 1. gene mutation 2. chromosome aberrations (deletions, translocations and inversions) 3. polyploidy and 4. hybridization. Probably all of the permanent variation in nature owes its origin to one or more of these mechanisms. In this paper, we are only concerned with the importance of the role of hybridization in speciation.

As indicated previously, there are many points of controversy about hybridization itself and it seems desirable to write on these points before assaying the role of the process.

The detection of hybrids. Species can be crossed artificially as bison × cattle and in such cases there can be no doubt regarding the origin of the hybrid. Wild hybrids may be intermediates of two species and measurements will usually serve to disclose the parentage with a high degree of certainty. In other cases, because of dominance and recessiveness, consider able analysis may be required to reveal the parentage. No doubt many hybrids in this third category exist and will remain undetected for some time to come. Some botanists believe that 50% or more of bad pollen is an indication of hybridity, but this is not an invariable guide because poor pollen may be due, in some cases, to low temperatures. Others believe that abnormal meiotic movements can be used to detect certain hybrids but Huskins (1929) points out that such irregularity may have no connection with hybridity. It can be positively stated that some known hybrids, as in the genera *Primula, Geum* and others, exhibit normal pairing at meiosis.

[1] Contribution No. 129 from the Department of Natural Science, Michigan State University. Paper read before the Michigan Academy of Science, Arts & Letters.

The sterility of hybrids. Another misconception about hybrids is that they are invariably or usually sterile. Many, of course, are sterile, but an imposing list of fully fertile hybrids can be made. The works of Stebbins (1945 and 1948) may be advantageously consulted on this matter. Also, it should be mentioned, that while some hybrids decrease in fertility with successive generations (*Zauschneria*), in others (*Viola* and *Bromus*) fertility may increase. It is generally believed that some sexually-impotent hybrids may maintain themselves by successful apogamous means. This fact adds immeasurably to the importance of the process under consideration. Sailor (1954) once wrote "the evidence has now piled up to a point where only the most obstinate of the uniformed continue to hold the belief that hybrid sterility is a necessary species criterion."

The relationship of nomenclature. Some biologists believe that nomenclature is at fault if two species cross readily. This can hardly be true on a wide scale because there are intergeneric hybrids, some between species in different families (as in birds) and some between species in different orders in fish (Robson 1928). To complete the picture, it must not be forgotten that some race crosses are unsuccessful. It seems fair to say that crossability is correlated to a large extent with gene homology and that this homology is not always correlated with morphological differences.

The swamping of hybrids. Some interpret the phenomenon of introgressive hybridization to imply that repeated backcrosses of hybrids with their parents swamp or eliminate the hybrids and thus no proliferation of species occurs. That this is not universally true was indicated by Rollins (1954) in his work on the genus *Lesquerella*. In this case, both hybrids and parents retained their distinctive identities. Other examples can be found in Huxley (1943) and in Mayr (1942).

One last fact which needs stressing is that which concerns the formation of multiple segregates from a cross(s) of two species. It is well known that the number of different phenotypes arising is a function of the number of pairs of heterozygous alleles. An individual having twenty pairs of heterozygous alleles can produce over 900,000 *different* gametes. It is not surprising, therefore, to find in the literature variously named hybrids arising from crosses of the same species.

In assaying the role of hybridization in speciation, the writer felt that it was important to know the approximate number of hybrids in nature. A large number could be taken to mean that the process was very effective in speciation. Several years ago, I estimated the number for members of this academy. Since that time, two books have been published by Annie Gray (1954 and 1958), one on bird hybrids and the other on mammalian hybrids. Furthermore, a continued search of the literature by the writer has revealed hybrids in other groups. The list below will therefore supersede the previous estimate.

AN ESTIMATE OF THE NUMBER OF REPORTED HYBRIDS

I. Animal Kingdom	
Mollusca	5
Arthropoda	233
Echinodermata	31
Chordata	2205
Protochordata	1
Pisces	167
Amphibia	101
Reptilia	37
Aves	1599
Mammalia	300
II. Plant Kingdom	
Schizomycophyta	2
Eumycophyta	54
Chlorophyta	8
Bryophyta	7
Pteridophyta	158
Spermatophyta	15000

There are more hybrids reported in the plant than in the animal kingdom, and we list below those families of the Spermatophytes having large numbers of hybrids.

Caryophyllaceae	150
Compositae	2100
Cyperaceae	400
Ericaceae	190
Fagaceae	320
Geraniaceae	700
Gramineae	960
Labiatae	400
Leguminosae	160
Onagraceae	320
Orchidaceae	2500[2]
Polygonaceae	180
Primulaceae	160
Ranunculaceae	215
Rosaceae	1860
Salicaceae	600
Saxifragaceae	270
Scrophulariaceae	540
Violaceae	450

Further analysis of the literature will reduce the numbers in some families as duplication is discovered and increase the numbers in other families. At present, intensive studies are being made of the Pteridophyta and of the Gramineae (Spermatophyta) and manuscripts on the hybrids in these groups are nearing the publication stage.

[2] This does not include all of the artificial hybrids of which there may be 30,000 or more, according to Gordon Dillon of the Amer. Orchid Soc.

It would be of great importance to know how many of the crosses were successful in producing fertile offspring. This will probably never be known with any great degree of certainty because investigators do not report on this aspect of the problem. However, there are enough fertile hybrids known in nature to justify the claim that crossing has been and still is an important method of speciation.

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THE CYTOLOGY OF XANTHISMA TEXANUM D.C. V. FURTHER OBSERVATIONS ON CYTOLOGY AND BREEDING BEHAVIOR[1]

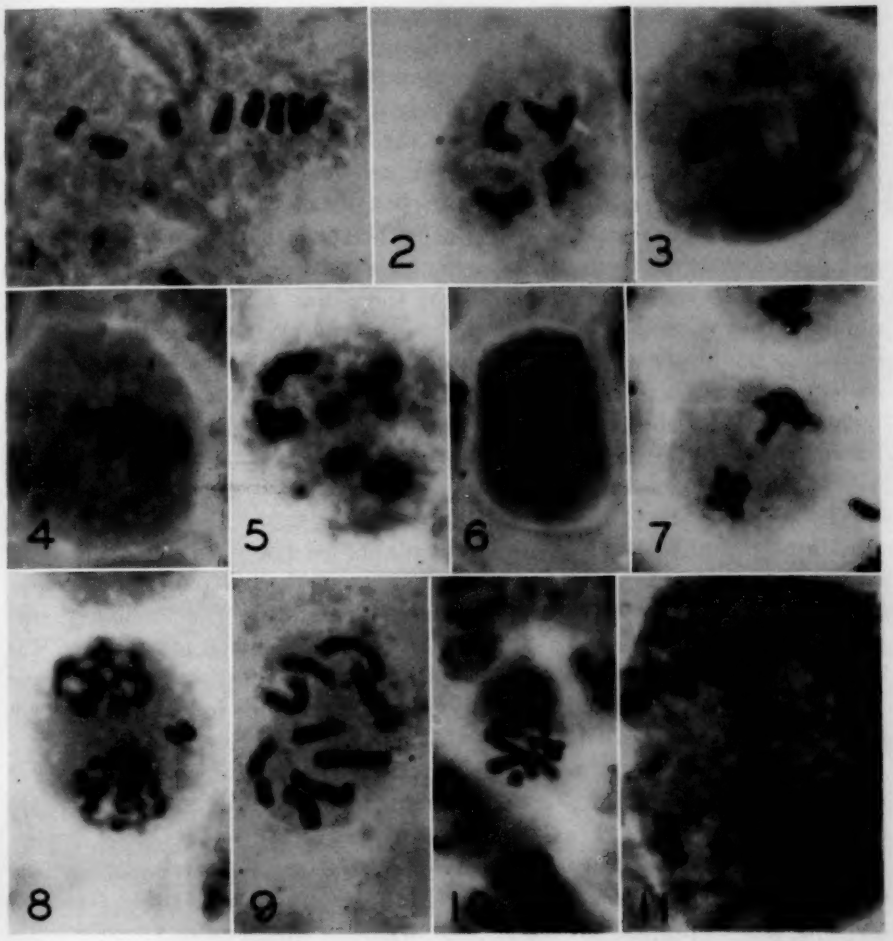
E. R. WITKUS, SR. J. BAPTIST FERSCHL AND C. A. BERGER

[1] This investigation was aided by a Grant (G-7091) from the National Science Foundation.

In a cytological study of *Xanthisma texanum* D.C., Berger and Witkus (1954) observed a difference in chromosome number between the cells of the root and the cells of the shoot. Root tip smears showed the chromosome number to be 2n = 8 (fig. 1). A study of the meiotic divisions in the pollen mother cells revealed that at the first meiotic division some plants had four bivalents (fig. 2), while other plants had five bivalents (fig. 3). Regardless of the meiotic count, all root tip cells had eight chromosomes. The cells of the tapetum and other somatic tissue of the anther of five bivalent plants had ten chromosomes. Thus the differentiation in chromosome number was not between germ cells and somatic cells but between root and shoot. A further study of the chromosome number of seedlings of *Xanthisma texanum* (Witkus, Lowery and Berger 1955) revealed other types of plants. Studies of microsporogenesis revealed three other strains, having four bivalents and one univalent (fig. 4), five bivalents and one univalent (fig. 5) and six bivalents. All of these additional strains also had the chromosome number of 2n = 8 in the cells of the root. The extra chromosomes were always of the same size and shape and showed normal meiotic pairing with each other, but never with any of the other four chromosomes of the haploid complement. The evidence therefore indicated a supernumerary chromosome which might be present one or more times in different individuals of natural populations. The chromosome was genetically inert.

In plants with two or more supernumerary chromosomes a few root cells with nine or ten chromosomes were found, especially in plants of the five bivalent and one univalent type. In the shoot tissue with the exception of germ cells some variation in chromosome number was found. Only the supernumerary chromosome was involved in these variations.

Berger, McMahon and Witkus (1955) reported a possible relationship between the loss of the chromosomes and root differentiation. In embryos of plants having one or more supernumerary chromosomes the differentiation of root tissue is accompanied by an elimination of the supernumerary chromosomes. In *Xanthisma texanum* the supernumerary chromosomes are present in all the cells of the young embryo up to the late spherical stage. Root and shoot tissues become differentiated at the heart-shaped stage of



FIGS. 1–11. Photomicrographs of aceto-orcein smear preparations of somatic and germ cells of *Xanthisma texanum* D.C. Magnification X 1750. FIG. 1. Somatic cell from the root tip showing eight chromosomes. FIG. 2. Diakinesis of a four bivalent plant. FIG. 3. Diakinesis of five bivalent plant. FIG. 4. Diakinesis of a four bivalent and one univalent plant type. FIG. 5. Diakinesis of a five bivalent and one univalent plant type. FIG. 6. Telophase I of a four bivalent and one univalent plant showing the equational first division of the supernumerary chromosome. FIG. 7. Telophase I of a four bivalent and one univalent plant showing the reductional first division of the supernumerary chromosome. FIG. 8. Interphase of a four bivalent and one univalent plant type showing a micronucleus. FIG. 9. Somatic cell from the shoot of a five bivalent plant type showing ten chromosomes. FIG. 10. Somatic cell from an adventitious root of five bivalent plant type showing twelve chromosomes. FIG. 11. Somatic cell from an adventitious root of a five bivalent plant type showing thirteen chromosomes.

the embryo, at which time the supernumerary chromosomes are eliminated and are seen for a time as micro-nuclei in the cytoplasm. The elimination of the supernumeraries was found to be due either to failure to congress on the metaphase plate or to lagging at anaphase; in both cases the supernumeraries are left in the cytoplasm becoming micronuclei which may persist for several divisions but are eventually lost.

The following study was made to obtain more information about the supernumerary chromosomes, especially their mode of transmission. This was done first by studying the number of supernumeraries in the progeny of each plant type noting especially if there was any mechanism for the numerical increase or decrease of the supernumeraries in the progeny. The constancy of the chromosome numbers in the germ cells was further studied by making cuttings of the plants when they reached the height of 3, 6 and 9 inches and then comparing the chromosome numbers of the germ cells of the previously decapitated plants with the chromosome numbers of the germ cells of the cutting. Adventitious roots of the cutting were also studied to check the constancy of the chromosome numbers in the shoots.

Material and methods. The parent plants used were grown from seeds collected the previous year from plants of each of the five plant types whose chromosome number had been determined. A total of sixty-five plants consisting of ten to eighteen progeny of each of the five plant types was studied. All the plants were grown in a greenhouse and no effort was made to prevent cross pollination. In studying chromosome behavior aceto-orcein smears were made of all the parts studied.

Observations. Seeds were collected from a plant of each of the five types and the progeny raised and examined cytologically. The results are shown in Table 1.

When the supernumerary chromosome exists as a univalent as is the case with plants having four bivalents and one univalent or five bivalents and one univalent, the univalent may divide at either of the two meiotic divisions (figs. 6 and 7). Usually the univalent passes undivided to one pole at anaphase I (fig. 7). The supernumerary chromosome usually lags behind the other chromosomes and divides at the second meiotic division. Thus, in plants which have the supernumerary chromosome existing as a univalent, there are two types of egg cells and two types of microspores possible. In the four bivalent and one univalent plant the egg cells and microspores can have either four or five chromosomes. In the five bivalent and one univalent plants the egg cells and microspores can have either five or six chromosomes. Therefore, three types of pollen were available for cross pollination of the flowers.

Sometimes when the supernumerary chromosome lags at anaphase, it fails to be incorporated in the daughter nuclei (fig. 8). In this manner it

is possible that the supernumeraries are lost in the cytoplasm. Cross pollination can account for most of the plant types obtained in this investigation. Studying the progeny confirms the cytological observation that all the supernumeraries are homologous. In the progeny of the 4 bivalent plant, seven plants were found having five bivalents. The five bivalent types could possibly have arisen if a four bivalent crossed with a six bivalent. In that case the two supernumeraries in the six bivalent act as bivalents.

In comparing the chromosome number of parent plants with cuttings, a total of forty-two sets of plants was used. A set of plants consisted of the parent plant and its respective cutting. Chromosome counts were determined by a study of the pollen mother cells at diakinesis or metaphase. The results showed that there was no difference in chromosome count between the parent and its respective cutting. Thus if a parent plant had four bivalents the cutting also had four bivalents. The same was true for all the

TABLE 1. *Progeny of each of the five parental plant types classified according to number of bivalents and univalents at meiosis.*

Parental Type	Progeny					
	4 biv.	4+1	5 biv.	5+1	6 bi.	6+1
4 biv.	3		7			
4+1	2	3	4	3		
5 biv.		11		2		
5+1		1	2	6	1	1
6 biv.	1	6	6	4	1	

other plant types. The distribution of chromosome counts for the forty-two sets of plants is as follows: 5 sets of plants had four bivalents; fifteen sets of plants had four bivalents and one univalent; twelve sets of plants had five bivalents; eight sets of plants had five bivalents and one univalent; two sets of plants had six bivalents.

A study was made of the cells of adventitious roots to check the constancy or variation of chromosome number in the shoot tissue. Some variation in chromosome number seems to be characteristic of the shoot tissue of *Xanthisma texanum* (figs. 9 to 11). After the chromosome count of the plants had been determined by a study of the pollen mother cells, cuttings of each of the five plant types were made and placed in sand to root. Acetoorcein smear preparations of the adventitious roots were studied to determine the variation in chromosome number present in the cells of the adventitious roots of the various plant types. The cuttings of fifteen plants were used for this study. The results are shown in Table 2. The plants used for the study of adventitious roots were derived from seeds collected the previous year from the following plant types. The four bivalent plants were progeny of four bivalent and one univalent and six bivalent plant

types. The four bivalent and one univalent plants were progeny of 4 bivalent and four bivalent and one univalent plant types. The five bivalent plants were derived from seeds of a five bivalent plant type. The five bivalent and one univalent plants were derived from the seeds of four bivalent and one univalent and five bivalent plant types. The six bivalent plants were derived from seeds of five bivalent and one univalent and six bivalent plant types.

It can be seen from Table 2 that in spite of a wide variation in the chromosome number of cells of adventitious roots, there is a clear tendency for their cells to have the same number as the parent plant. It is likewise clear that while some cells lose chromosomes other cells gain them. This would seem to indicate that non-disjunction of supernumeraries may well be the chief cause of this variation. Successive non-disjunction could account for the very high numbers of chromosomes, e.g. twenty-two and twenty-four, which are rarely found.

TABLE 2. *Variation in chromosome number of cells of adventitious roots of cuttings from plants of known type.*

Type	Chromosome number											
	8	9	10	11	12	13	14	15	16	20	22	24
4 biv.	431	14	22		9		1		1	5		
4+1	808	312	31		15		6		5			
5 biv.	133	24	175	11	16		4		2			
5+1	16	6	10	44	2						1	
6 biv.	121	43	151	31	192	21	13	5	8	3	1	1

Non-disjunction, however, is not the mechanism by which elimination of supernumeraries occurs in the early embryology of the primary root. Cytological evidence clearly shows that this early elimination is due to either failure of congression on the metaphase plate or to lagging at anaphase and is followed by formation of micronuclei.

Although variation was evident in the shoot and in adventitious roots arising from the shoot, no variation was ever noted in the flowers. This would indicate the possible presence of a germ line, in which the chromosome number remains constant, once it becomes established.

Discussion. The extra chromosomes found in *Xanthisma texanum* are referred to as supernumerary chromosomes and they resemble the B-chromosomes of *Zea* and *Sorghum*. There is one important difference in *Xanthisma*, however, in regard to the location in the plant of the supernumerary chromosomes. In *Sorghum*, the supernumerary or B-chromosomes are confined to the germ-track (Janaki-Ammal 1940 and Darlington and Thomas 1941). They are lost in the radicle before seed ripening and in the shoot tissue as they reach maturity. In *Xanthisma*, the supernumerary chromo-

somes are not confined to the germ track, although they indicate the presence of a germ-track by the constancy of chromosome number of germ cells while the somatic cells show considerable variation. Berger and Witkus (1954) found that there is a difference between root and shoot tissues. Witkus, Lowery and Berger (1955) reported that in plants having supernumerary chromosomes, less than 2% of dividing cells of the root were found with nine or ten chromosomes and these variations occurred in the five bivalent and one univalent plants. They stated that the presence of the supernumerary chromosomes in the root cells was probably due to failure of chromosome elimination in early development of the plant. Variations of a similar kind were also found in the cells of the shoot, but in much higher numbers. The variation always involved only the supernumerary chromosomes.

Constancy of supernumerary chromosomes. Although some variation was found in the cells of the shoot, the chromosome number of the germ cells was constant in the individual plant. This constancy was also found between the germ cells of the cutting and those formed anew on decapitated parent plants. This was found to be true in forty-two sets of cuttings and parent plants.

Östergren (1947) noted that in *Anthoxanthum* the B-chromosomes are rather constant in the various parts of the plants. The chromosome numbers of root and shoot were the same with only slight variation. The same was true for the accessory chromosomes of Festuca (Bosemark 1954).

In *Sorghum* (Janaki-Ammal 1940 and Darlington and Thomas 1941) and in *Poa* (Muntzing 1946) accessory chromsomes are present only in the germ line and are eliminated in the root tips and other somatic tissues.

The supernumerary chromosomes of *Xanthisma* differ from any of these cases in that there is a difference between root and shoot and not merely between germ line and somatic tissue. The cells of the primary root are constant and always show eight chromosomes; they rarely contain supernumerary chromosomes. In plants with supernumerary chromosomes, elimination of the supernumerary chromosomes from the root occurs in early embryology while they are retained in the shoot. The supernumerary chromosomes are present in all the cells of the young embryo until the late spherical stage. Differentiation of root and shoot tissues occurs when the embryo changes from the late spherical stage to the heart-shaped stage. The supernumerary chromosomes are eliminated from the cells of the root tissue due to the lagging of the supernumeraries at anaphase of mitosis and also by a failure to congress on the metaphase plate. When this occurs, the eliminated supernumeraries form micronuclei and are eventually lost in the cytoplasm (Berger, McMahon and Witkus 1955).

Behavior of supernumeraries in sporogenous tissue. It is a character-

istic of supernumerary or B-chromosomes that they do not pair with those of the normal complement during meiosis. If a single supernumerary chromosome is present, it behaves as a univalent and may divide in either of the two meiotic divisions. Usually the univalent passes undivided to one pole at anaphase I and then divides equationally at the second meiotic division.

If two supernumeraries are present, they may or may not pair with each other. Uusually they do pair and behave as other bivalents of the normal complement. Lagging at anaphase I usually does not occur when they exist as bivalents.

When three supernumeraries are present, two of them may pair and one may remain as a univalent or all three may function as univalents.

There was some evidence in this investigation that all the supernumeraries in *Xanthisma texanum* are homologous. This was evident in the five bivalent plants which arose from seeds of four bivalent plants. The five bivalent plants must have resulted because of cross pollination of the four bivalent plant with a six bivalent plant. Pollen from a six bivalent plant would have the chromosome constitution of four chromosomes of the normal complement plus two supernumeraries. When pollen of this type fertilizes the egg cell of four bivalent plants, the result will be seeds which will give rise to five bivalent plants. Pollen mother cells of the five bivalent plants usually showed five bivalents at diakinesis or metaphase. Thus the two supernumeraries brought in by the pollen must have been homologous since they paired with each other.

Variation in progeny. A considerable variation in chromosome number was noted in the progeny grown from seeds of the five plant types. It is interesting to note that the plants carrying supernumerary chromosomes were in predominance and of the sixty-five plants studied, fifty-nine had the supernumerary chromosomes. Cross pollination normally takes place in the Compositae. Non-disjunction of supernumeraries and cross pollination can account for the plant types obtained in this investigation as listed in Table 1.

Supernumerary chromosomes in adventitious roots. In this study a variation in chromosome number was found in the cells of the adventitious roots of *Xanthisma*. All five plant types were used and all showed this variation in different degrees. It was expected that the four bivalent plants would have shown no variation at all in the cells of the adventitious roots. However, a variation did occur and it is probably due to the fact that all four bivalent plants used for the study of the adventitious roots were not of a pure four bivalent lineage. The two plants used had been derived from seeds of a four bivalent and one univalent plant and a six bivalent plant.

In the cells of the adventitious roots of the four bivalent and one uni-

valent plant the diploid number (8) was dominant, but a considerable number of the cells showed the number characteristic for the shoot. In the five bivalent, five bivalent and one univalent and six bivalent plants the predominant number was the number characteristic for the shoot. The variation in chromosome number always involved the supernumerary chromosomes.

It is probable that the variations in chromosome number observed in the cells of the adventitious roots are brought about by non-disjunction of the supernumeraries. As the chromosomes are lost from one cell they are apparently gained in others and thus give rise to a variation in chromosome number. In the primary roots, on the other hand, they are completely lost.

SUMMARY

1. No difference in chromosome number between parent plant and cutting was observed in any of the plant types examined. A study of microsporogenesis revealed that both the parent plant and cutting had identical chromosome numbers. There was some indication that the chromosome number of the flower was determined early in development and that in these cells no subsquent variation occurred. This would indicate the possible presence of a germ track.

2. Seeds from each of the plant types gave rise to progeny of various chromosomal constitutions. The majority of the plants had one, two or three supernumerary chromosomes. This variation could be explained by non-disjunction or cross pollination.

3. The evidence indicated that all the supernumeraries were homologous.

4. A study of adventitious roots revealed a variation in the number of chromosomes within each of the plant types.

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STUDIES ON AMERICAN HEPATICAE. 7. A SUPPLEMENT TO "THE GENUS BAZZANIA IN CENTRAL AND SOUTH AMERICA."

PART 1. INTRODUCTION AND THE SUBGENUS BIDENTATAE

MARGARET FULFORD[1]

In the 13 years since the publication of my taxonomic study of the species of *Bazzania* of the West Indies, Central and South America (Fulford 1946) a great number of recent and older unnamed collections have become available for study, including more than 400 specimens of *Bazzania*. Also, there has now been an opportunity to examine 450 specimens from the Stephani Herbarium and other collections at Geneva, through the kindness of Dr. C. E. B. Bonner of the Conservatoire et Jardin botaniques, which were not available during World War II when the earlier study was under way.

In several instances the specimens in the Stephani Herbarium at Geneva differ from the duplicates in the Micro-herbarium from Stephani at the Farlow Herbarium of Harvard University. The latter were the only authentic material of Stephani's species available in this country at that time. Since the first set of specimens is at Geneva and in orthodox procedure it has priority, the discrepancies have necessitated certain changes in the concepts of certain species.

The study of this large genus has always been beset with major difficulties, for the problem of delimiting the individual species is an exceedingly confusing one. In the first place, in plants of any given locality, there is often a tremendous variation in the size and form of the stems, the form of the leaves, and the thickness of their cell walls. This variation tends to increase with variation in habitat and with increasing range of distribution. In the second place, in addition to this sort of variation, it often appears that an introgression among several species (a phenomenon of which we know nothing in the leafy Hepaticae), has frequently occurred. Spruce (1884–1885, p. 368), who had collected extensively in tropical America where many of the species are abundant, focused the problem very clearly when he stated that, "The species of this genus are a standing puzzle to the hepaticologists. They are all so alike in habit and in their obvious characters that a casual observer would unhesitatingly refer them to the same genus; and when we try to define the species, we find it difficult to assign them positive limits. Out of the mass of material I amassed in the

[1] Work related to a project supported by National Science Grant no. G 2616.

forests of the Amazon and Andes, I could easily form double the number of species here recorded . . ."

On the whole, my own interpretation of the species has been more conservative than that of Spruce,—and Stephani, but there remains much room for difference of opinion in the interpretation of the limits of the many species.

In this supplement to the earlier monograph (Fulford 1946), the arrangement of the Subgenera, Sections, and the Species follows in the same order. The changes include, the description of species new to science, the description of several species not available for the earlier study, drawings of these, the additional synonomy, additional detailed data on distribution, and revised keys to the species of all of the Sections.

I wish to thank the Director, Dr. C. Baehni and Dr. C. E. B. Bonner of the Conservatoire et Jardin bontaniques at Geneva for the loan of the large number of specimens including those from the Stephani Herbarium. Many other Herbaria and collectors have kindly loaned me the large quantity of unnamed collections and I am grateful for their kindness. These are listed under the individual citations and the herbarium abbreviations follow the standard form. My colleague, Dr. Harry R. Muegel has prepared the latin diagnoses. I wish, also, to express my appreciation to my assistants, Miss Jane Taylor and Dr. Raymond Hatcher, who have helped in all parts of the preparation.

BAZZANIA S. F. GRAY, NAT. ARR. BR. PL.
1: 704. 1821.

The genus is a large one with species in all parts of the world but with the greatest concentration of species in tropical and subtropical areas. It is an old genus geologically and the species, in most instances, can be readily segregated into two Subgenera and five Sections.

KEY TO THE SUBGENERA

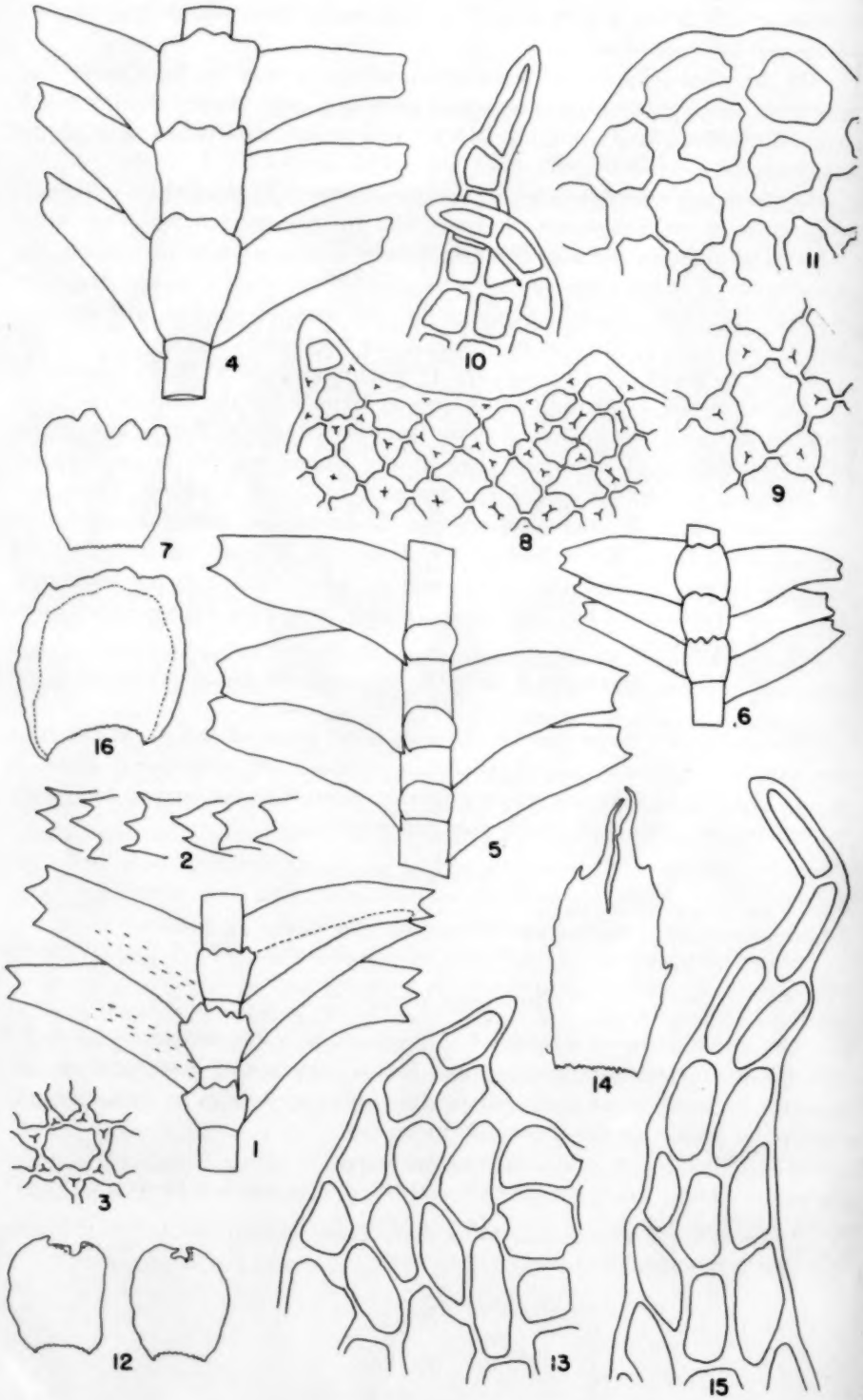
Leaves predominantly two-toothed ..... Bidentatae
Leaves predominantly three-toothed, occasionally only faintly so, or rarely entire ..... Tridentatae

SUBGENUS BIDENTATAE

The outstanding character of this subgenus is the bidentate apices of the leaves. Occasional three-toothed leaves may occur more or less frequently on some stems and most of the species appear to be rather closely related to species in the Section Tridentatae.

KEY TO THE SPECIES

Stems coarse thread-like to delicate filiform, slender; in green to dark brown mats.
Leaves caducous, vittate; underleaves small, distant, scarcely divided.....7. *B. gracilis*
Leaves persistent, often reduced or deflexed.


4
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Leaves with a vitta of larger, thin-walled cells with conspicuous trigones.
Underleaves scarcely as broad as the stem, the apex faintly lobed or toothed ..... 7. *B. gracilis*
Underleaves broader than the stem, irregularly and coarsely incised or toothed; teeth of the leaves with crenulate margins; the vitta not very conspicuous ..... 2. *B. phyllobola*
Leaves without a well marked vitta.
Cells of the apical portion of the leaf mostly 24–36 μ, the trigones very large and rounded ..... 6. *B. roraimensis*
Cells of the apical portion of the leaf mostly 18–24 μ, the trigones small, conspicuous ..... 4. *B. cuneistipula*
Stems not filiform, larger, the leaves spreading.
Plants with leaves narrow-elongate to elongate-ovate.
Margins of the teeth entire; underleaves subquadrate, distant to imbricated, the apical margins only faintly two- to four-lobed ..... 1. *B. bidens*
Margins of the teeth more or less crenulate; underleaves with variously and deeply incised, toothed and lobed margins, broader than the stem ..... 2. *B. phylloloba*
Plants with leaves unsymmetrically ovate.
Leaves with a vitta.
Underleaves broader than the stem, with variously and deeply incised, toothed and lobed margins ..... 2. *B. phyllobola*
Underleaves not broader than the stem, the lateral margins undivided.
The ventral margins of the leaf strongly convex, arcuate; the teeth broad, the acroscopic tooth usually the larger; cells of the apical portion with conspicuous trigones, often coalesced ..... 3. *B. herminieri*
The ventral margin of the leaf scarcely convex; the teeth equal or nearly so, the trigones small, rarely conspicuous ..... 7. *B. gracilis*
Leaves without a vitta; the teeth short, the sinus broad, lunulate.
Cells of the apical portion of the leaf 24–36 μ, the trigones very large and rounded ..... 6. *B. roraimensis*
Cells of the apical portion of the leaf 18–24 μ, the trigones small, conspicuous, often coalesced ..... 4. *B. cuneistipula*

FIGS. 1–3. *B. phylloloba*. FIG. 1. Portion of a stem, ventral view, showing both two- and three-toothed leaves, × 30. FIG. 2. Apices of leaves, × 30. FIG. 3. A cell from the apical portion of a leaf, × 360. FIGS. 4–11. *B. roraimensis*. FIG. 4. Portion of a robust plant, ventral view, × 30. FIG. 5. Portion of a slender plant, ventral view, × 30. FIG. 6. Portion of a plant, ventral view, × 15. FIG. 7. Underleaf, × 38. FIG. 8. Portion of the apical region of a leaf, × 290. FIG. 9. A cell from the apical portion of a leaf, × 360. FIG. 10. Tip of a scale of a flagelliform branch, × 290. FIG. 11. Portion of a transverse section of a stem, × 290. FIGS. 12–15. *B. pallide-virens*. FIG. 12. Underleaves, the dotted lines at the tip indicate hyaline areas, × 40. FIG. 13. Portion of the apical margin of an underleaf, × 360. FIG. 14. Female bract of an intermediate series, × 40. FIG. 15. Upper part of one of the segments of this bract, × 360. FIG. 16. *B. stolonifera*. Underleaf, with the hyaline border indicated by a dotted line, × 30. Figures 1–3 drawn from the original material of *M. heterophyllum* collected by Allioni in Ecuador (G); figures 4, 5, 7–11 from a portion of the original of *M. roraimense* collected by McConnell & Quelch in British Guiana (G); figure 6 from a portion of the type of *B. platystipula* collected by Underwood in Jamaica (Fulford Hb.); figures 12–15 from a portion of the original of *M. pallide-virens* collected by Glaziou in Brazil; figure 16 from a portion of the original of *M. azuayense* collected by Allioni in Ecuador (G).

1. BAZZANIA BIDENS (Nees) Trevis.
Habitat: Over rocks, logs and on trunks of living trees.
Distribution: Puerto Rico: add, without locality, Schwanecke 729 (G).—Guadeloupe: add, without locality, l'Herminier 129 (G).—Dominica: add, Morne Trois Pitons, Elliott 2316 (BM, G).—Martinique: add, Mt. Peleé, Husnot 246b (G).—Colombia: Rio Kananarí, Schultes and Cabrera 14454a, p.p. (US); Rio Kuduyarí, Schultes and Cabrera 14466b (US).—Venezuela: Serrania Parú, Cowan & Wurdack 31425 (NY).—French Guiana: (original, FH, G), add, St. Jean. Hb. Thériot (G); Cayenne, Feé 19 (G); without locality, Leprieur 676, as *M. stoloniferum* var. *bidens* (G).—Guiana.—Peru.

2. BAZZANIA PHYLLOBOLA Spruce. Figures 1–3.
add syn. *Mastigobryum heterophyllum* Stephani, Spec. Hep. **6**: 466. 1924. syn nov.; [Icones Hep. *Mastigobryum* no. 346].

This species when well-developed is easily recognized by the deeply bifid, elongate-rectangular, spreading leaves which are only slightly bulging on the dorsal side below. The cells of the middle of the leaf are elongate and form a more or less distinct vitta. The two teeth are usually large and are clearly crenulate. The underleaves which are large and broader than the stem are irregularly incised-toothed. Unfortunately, the smaller forms are often not so distinct. The shorter leaves tend to be more ovate and to have shorter, less conspicuously crenulate teeth, and the underleaves are smaller and less lobed and incised. When branches bearing such leaves are attached to stems with the characteristic underleaves there is no problem, but when one finds such smaller stems alone, they present difficulties since they approach some of the variations of *B. gracilis* and there is no certain way of distinguishing the two. The mouth of the perianth differs in the two in that, in *B. phyllobola*, it is densely long ciliate, while in *B. gracilis* it is divided into numerous long laciniae. Unfortunately, perianths are rarely found even on robust material. Undoubtedly some of the collections (small forms) of *B. phyllobola* are listed under *B. gracilis* below, but until detailed culture studies are made there is little hope of distinguishing between certain forms of the two species.

In most collections occasional three-toothed leaves are not uncommon on characteristic stems and such a condition is more common in plants of some localities than in others. The plants of the original collection of *M. heterophyllum* Stephani, collected by Allioni in Brazil, have both bifid and trifid leaves alternating on a single stem (see figures 1, 2). The stems are the size of the original material of *M. dissodontum* (the more robust expression of *B. phyllobola*) but most of the leaves are less deeply divided and more of the leaves are three toothed. The underleaves of *M. heterophyllum* are somewhat smaller and are not so strongly toothed or incised and the lateral margins are undivided. The cell pattern and the general form of the two is otherwise identical. The leaves are unsymmetrically ovate, the vitta is

more or less distinct, the size of the cells in the upper part varies considerably, and the trigones are distinct (Fig. 3).

The problem of where to assign plants like *M. heterophyllum*, with both bifid and trifid leaves on a single stem is a difficult one. Such transitional forms are present in most of the species of the subgenus *Bidentatae*.

Habitat: On tree bases and trunks, forests in the mountains.
Distribution: Colombia: add, Rio Apopores, Raudal Yapscopi, Schultes, Cabrera & Bell 15438 p.p. (FH); Dept. del Valle, Cordillera Occid., Cuatrecasas 22082-B (US).—Venezuela: Estado Bolivar, Chimanta Massif, Abacapa-Tepui, Steyermark 75216 p.p., 75645, 76017 (NY).—British Guiana: Roraima 8600′, McConnell & Quelch 532 (G).—Brazil: add, S. Paulo: Santos, Schiffner 886 p.p. (W); n'r Rio Grande, Schiffner 1096 p.p. (W); Santos: St. Vincent, Horeau 6 (G); Minas Geraes: Caraça, Wainio 18 (G); subtropics, Ule 304 (G)—Ecuador, Azuay: Gualaquiza, Allioni (hb. Levier 6577), original of *M. heterophyllum* (G); Oriente-V. Bomboiza, Allioni, Bryol. Ecuad. 706 (G)—Peru: (original, G. FH).

3. Bazzania herminieri (Steph.) Pagán, Bryol. **45**: 90. 1942.

Habitat: On rocks, stones and tree bases.
Distribution: Guadeloupe: (original, FH, YU, NY, G); add, without locality, Marie (G); forêt de Baines Jaunes, Le Gallo 225 p.p., 233, 247, 252, 254, 275 (Le Gallo); Galion, Le Gallo 263 p.p., 264 p.p., 277 (Le Gallo).—Martinique: add, without locality, 610 m., Duss 62 (G).

4. Bazzania cuneistipula (G. & L.) Trevis.

Habitat: On trees and logs in woods.
Distribution: Cuba.—Jamaica: (original, V., G.); add, Morce's Gap, Lewis & Bangey 303 (IJ); Fairy Glade, M. Farr 777 (IJ); summit of High Peak, M. Farr 915 (IJ); n'r Cinchona, M. Farr 1453 (IJ); without locality, Harris, as *M. tenerum* (G).—Puerto Rico.—Guadeloupe: without locality, Duss 1034, as *M. tenerum* (G).—Martinique.—St. Vincent: without locality, Breutel (G).—Trinidad: add, Tucuche, Crüger (G).—Colombia.—Brazil.

5. Bazzania platystipula Fulford = B. roraimensis (Steph.) Fulford.

6. Bazzania roraimensis (Steph.) Fulford. Figures 4–11. add syn. *Bazzania platystipula* Fulford, Bryol. **44**: 145–146. 11 fig. 1941. syn. nov.

The earlier interpretation and discussion of *B. roraimensis* and the figures (Fulford, 1946, p. 29, f. 7) were based on the portion of the original collection by McConnell and Quelch from Mt. Roraima in British Guiana, at the Farlow Herbarium. The portion of the original collection in the Stephani collection at Geneva (a larger mat of plants) contains not only small stems of the sort described, with distant leaves and distant orbicular underleaves, but also more robust, well developed stems with closely imbricated leaves and large, subquadrate underleaves with deeply four-lobed apices (see Figures 4, 5). Plants of this latter sort, collected in Jamaica by Underwood, no. 692, were described as new under the name *B. platystipula* Fulford, which now becomes a synonym (Fig. 6).

B. roraimensis is a distinctive species which may be recognized by its greenish-brown to golden-brown stems with ascendant leaves which are bifid with short, equal teeth separated by a broad shallow sinus. The leaf cells are large, mostly 24–36 μ, thin-walled, with an angular-rounded to stellate lumen and large trigones with bulging sides (Figs. 8, 9). Figures 4–7 show some of the variation in size and form within the species. Some of the more robust stems bear a considerable number of three-toothed leaves.

Habitat: On tree bases and logs, in mats or scattered among other bryophytes.
Distribution: Jamaica: John Crow Peak, 5000–5800 ft., Underwood 692, type of *B. platystipula,* (Fulford Hb., NY, YU); summit of John Crow Peak, M. Farr 969, 990 (IJ); Blue Mountain Peak, Patterson 23 (Fulford HB.); summit of High Peak, M. Farr 904 (IJ); n'r Cinchona, M. Farr 1453 (IJ).—Puerto Rico:—Luquillo Mountains, E. G. Britton (NY).—Colombia: Dept. Norte del Santander, Cuatrecasas 12449-B (US).—British Guiana: summit of Mt. Roraima, McConnell & Quelch 518 (G); the same, 523, (original, FH, G).—Guiana: without locality, Quelch 11 (G).—Brazil: S. Paulo: n'r Taipus, Schiffner 1021 p.p. (W); Sevilla, 3400 m., Karling 2338 p.p. (HB. Herzog).

7. BAZZANIA GRACILIS (H. & G.) Stephani.

This abundant, widespread species is characterized by its small size, slender to filiform stems and small, ascendant, vittate leaves (often scale-like on filiform stems), which are often caducous. Cells of the upper part of the leaf are, for the most part, uniformly thickened. On the smaller stems, the underleaves are entire or one- to four-toothed or lobed at the apex. On more robust stems the underleaves tend to be larger, slightly broader than the stem and longer and closer together. The latter are variously lobed or short incised at the apex and may be somewhat lobed along the lateral margins. Such plants are uncomfortably similar in size and form to small plants of *B. phyllobola* and undoubtedly some atypical or depauperate forms of the latter species have been included in the list below.

The well developed leaves are unsymmetrically ovate, vittate, bifid, with the acroscopic tooth usually the longer and with margins entire while characteristic leaves of *B. phyllobola* have longer, crenulate teeth. Two collections from Venezuela, Alston no. 5586 and Cowan & Wurdack no. 31268, differ from the rest of the material in that many of the leaves are rounded-entire or acute at the apex. The bifid leaves have very short teeth with a shallow, lunulate sinus. The general habit of the plants is otherwise characteristic for this species.

Habitat: Tree bases, logs and over rocks and soil in forests.
Distribution: Cuba: Oriente, Sierra Maestra, Morton 9443, 9529 (US).—Jamaica: add, without locality, Börgensen, as *M. cuneistipulum* (G); without locality, Hausen (G); Fairy Glade, M. Farr 769, 779, 783, 784, 787 (IJ); Caledonia Peak, M. Farr 1009 (IJ); between Sir Johns and High

Peaks, Lewis 70 (IJ); n'r John Crow Peak, M. Farr 930 (IJ); Hardware Gap to waterfalls, M. Farr 1213 (IJ); without locality, Sherring 8 (BM); without locality, Orcutt 3170, 5107 (BM); Hardware Gap, Baxter 9 p.p., 11 p.p. (KANU); New Haven Gap, Underwood, 911, as *B. cuneistipula* (YU, NY).—Puerto Rico: (the original, B, FH, G).—Guadeloupe: without locality, l'Herminier, as *M. cuneistipulum* (G).—Martinique: without locality, Duss 638, as *M. cuneistipulum* (G).—Honduras: n'r Achote, Yuncker 6615 p.p. (DPU).—Guatemala: add, Alta Verapaz, Türckheim, hb. Levier 5822, as *M. phyllobolum* (G).—Colombia: Serra do la Mascasena, Phillipson & Idrobo 2131 p.p., 2158 p.p. (BM); Rio Miritiparana, Schultes & Cabrera 15789 (FH); Rio Papuri, Schultes & Cabrera 19458 (FH).—Venezuela: Serranía Parú, Cowan & Wurdack 31268 (NY); above Maturin n'r Las Trincheras, Alston 5586 (BM).—British Guiana.—Ecuador.—Brazil: add, Minas Gerais, Caraça, Wainio 13, as *M. phyllobolum* (G).

STUDIES ON AMERICAN HEPATICAE.
8. A SUPPLEMENT TO "THE GENUS BAZZIANA IN CENTRAL AND SOUTH AMERICA."
II. TRIDENTATAE (1 & 2)

Subgenus Tridentatae

Plants with leaves three-toothed (sometimes with occasional bifid leaves), in a few species the leaves entire or nearly so.

Key to the Sections

Leaves with a conspicuous vitta ..... 5. Vittatae
Leaves without a vitta (in a few of the species there is the suggestion of one).
  Underleaves connate with one or both leaves; leaf margins entire, inconspicuously serrulate to strongly dentate ..... 2. Connatae
  Underleaves free from the leaves; leaf margins not serrulate (several exceptions).
    Underleaves divided to the middle into long lobes or teeth (no representatives reported for the Western Hemisphere) ..... 3. Fissistipulae
    Underleaves more or less entire or not more than one-third divided into lobes or teeth.
      Leaves with a conspicuous, usually appendiculate ventral auricle; underleaves large, cordate, attached in a recurved line; the line of leaf insertion curved in the upper part, the dorsal end bent downward forming a hook ..... 4. Appendiculatae
      Auricles of the leaves, if conspicuous never appendiculate (a few exceptions); underleaves attached in a straight or sometimes a curved line; the line of leaf insertion curved to hookform above ..... 1. Grandistipulae

Section 1. Grandistipulae

Plants large to small, leaves without a vitta (rarely faintly developed), or conspicuous auricles or appendages (except in *B. arcuata* and *B. denticulata*), the teeth with entire margins (crenulate and toothed in *B. dentic-*

ulata; serrate in *B. serrata* & *B. chimborazensis*) the underleaves attached in a straight or sometimes a curved line, free from the leaves.

KEY TO THE SPECIES

Underleaves, in part, of hyaline cells which often form a conspicuous border.
- Leaf margins serrate throughout, leaves mostly three-toothed ..... 10a. *B. serrata*
- Leaf margins not serrate.
  - Leaf cells thin-walled, trigones absent or minute; underleaves hyaline except for a small internal area at the base ..... 8. *B. affinis*
  - Leaf cells thin-walled, trigones small to conspicuous, often with bulging sides, the cell lumina angular-rounded.
    - Underleaves longer than broad, to one-third or three-fourths hyaline, the apex variously incised or spinose, the lateral margins scarcely bulging; the leaves elongate, the teeth usually coarse, the cells mostly 36 μ ..... (forms of) ..... 9. *B. pallide-virens*
    - Underleaves subquadrate-rounded, the hyaline border continuous to the base.
      - Hyaline cells thin-walled, without trigones, chlorophyllose cells of the interior with conspicuous trigones ..... 10. *B. stolonifera*
      - Cell walls and trigones of the hyaline and chlorophyllose areas similar.
        - Hyaline border narrow, of one to four rows of cells; teeth of the leaves usually ending in a one-celled point; the cuticle coarsely verruculose ..... 11. *B. chilensis*
        - Hyaline border variable, narrow or including half the underleaf, or absent; teeth of the leaves usually ending in a two-celled point; the cuticle faintly verruculose ..... 12. *B. taleana*

Underleaves chlorophyllose throughout (rarely with a few scattered hyaline cells on the margin.
- Underleaves variously toothed or deeply lobed to incised, spinose or dentate in the apical portion and often on the lateral margins.
  - Underleaves spinose-dentate and ciliate to the base ..... 13. *B. denticulata*
  - Underleaves coarsely toothed, broad lobed, or irregularly incised, never ciliate.
    - Underleaves deeply four-lobed or variously incised and with a few spinose teeth in the upper part.
      - Underleaves twice as long as broad, with four long, rounded lobes ..... 23b. *B. elongata*
      - Underleaves about as broad as long.
        - Plants very robust, green; leaves with large more or less serrate teeth; underleaves very large, subquadrate and strongly cordate, the margins broadly lobed and undulate, with scattered hyaline cells on the apical margin ..... 17a. *B. chimborazensis*
        - Plants large to small; underleaves not strongly cordate, mostly broadest above the middle, hyaline cells absent.
          - Underleaves deeply four-lobed (at least those subtending the flagelliform branches); leaf cells mostly 20–24 μ ..... 14. *B. quadricrenata*

Underleaves variously and irregularly incised-lobed above and on the margins; leaf cells mostly 24–36 μ, the trigones large, knot-like ..... 15. *B. aurescens*

Underleaves mostly shortly incised or with only a few short incurved teeth on the apical margin.

Leaf cells mostly 27–48 μ in length.

Some underleaves hyaline above or throughout; the teeth of the leaves long and sharp (rarely short) ..... 9. *B. pallide-virens*

Underleaves never hyaline.

Underleaves twice as long as broad, deeply four-lobed ..... 23b. *B. elongata*

Underleaves about as long as broad, faintly lobed between two incurved teeth ..... 23a. *B. sublonga*

Leaf cells mostly 18–24 μ in the apical part.

Plant small, leaves ascendant, vittate; underleaves orbicular ..... (Vittatae). 43. *B. spruceana*

Plants larger, leaves mostly spreading, without a vitta; underleaves broadest above the middle, cells 20–24 μ ..... 16. *B. glaziovii*

Underleaves with entire margins, or the apical margin retuse, or with three or four broad shallow lobes and an occasional short spine.

Underleaves subquadrate.

Plants large, green; underleaves cordate at the base.

Lateral margins of underleaves entire, convex, recurved, the apex retuse ..... 18. *B. acuminata*

Lateral margins of underleaves plane, often undulate or sinuate, convex.

Apical margin of underleaves lobed, incised, and with scattered spines and teeth and occasional hyaline cells; lateral margins lobed ..... 17a. *B. chimborazensis*

Apical margin of underleaves entire or undulate with four broad lobes (rarely with a spine).

Leaves strongly arcuate from a conspicuous rectangular ventral appendage underleaves broadest at the base ..... 25a. *B. arcuata*

Leaves spreading or only slightly ascendant or decurved, a ventral auricle scarcely developed ..... 17. *B. breuteliana*

Plants large, yellow-brown to deep red-brown.

Underleaves deeply 4-lobed, twice as long as broad ..... 23b. *B. elongata*

Underleaves never deeply 4-lobed.

Underleaves crenate-undulate, not cordate at the base; leaves long, the teeth very long and coarse; cells of the apical portion large, 45 × 27 μ, the walls uniform, very thick and with small pits ..... 23c. *B. crassidentata*

Underleaves cordate-auriculate, attached in a recurved line (see Section *Appendiculatae*).

Plants smaller, not as above.

Teeth of the leaves very small to obscure, cells of the apical region mostly quadrate, trigones small; underleaves distant, the margins entire ..... 19. *B. diversicuspis*

Teeth of leaves well developed.

Underleaves small, rounded, distant; leaf apices broad, transversely truncate, trigones conspicuous ..... 20. *B. tricuspidata*

Underleaves approximate to imbricated, broader than the stem.

Leaf cells mostly 30–36 μ, the trigones very large, knot-like; leaves spreading to falcate, the teeth often coarse, sharp pointed; the plants yellow brown to red brown ..... 23. *B. longa*

Leaf cells mostly less than 28 μ, the trigones small.

Leaves ascendant, obliquely truncate, the cells mostly 24 μ (rarely to 30 μ) with small, conspicuous trigones ..... 21. *B. longistipula*

Leaves spreading to falcate or decurved.

Plants green to greenish-brown; underleaves often with a hyaline margin; leaf cells 16–20 μ × 18 μ, the walls thin, the trigones inconspicuous ..... 12. *B. taleana*

Plants olive to brownish or becoming reddish; the underleaves, squarrose, never hyaline; leaf cells 20–26 μ × 22 μ, the walls thin, the trigones small, conspicuous ..... 21a. *B. tricrenata*

Underleaves longer than broad, rectangular in outline, the bases not cordate.

Leaves ascendant, obliquely truncate, cells 24 μ (rarely to 30 μ), trigones small, conspicuous, plants green to yellow-brown ..... 21. *B. longistipula*

Leaves spreading, sometimes becoming falcate.

Underleaves entire, usually faintly lobed at the apex.

Leaves spreading, long, teeth median size, leaf cells mostly 24 μ, trigones small but conspicuous ..... 22. *B. latidens*

Leaves spreading to falcate, the teeth often coarse, often ending in a spine, leaf cells 30–36 μ, with very large trigones ..... 23. *B. longa*

Underleaves with a few spines, teeth, or lobes on the apical margin.

Underleaves deeply 4-lobed ..... 23b. *B. elongata*

Underleaves not deeply 4-lobed.

Plants green becoming brownish, leaf cells mostly 30–36 μ, with large knot-like trigones ..... 9. *B. pallide-virens*

Plants deep brown becoming blackish, leaf cells mostly 40–45 μ, the walls very thick from coalesced trigones ..... 23b. *B. crassidentata*

Underleaves oval to reniform, rounded to cordate at the base.

Underleaves reniform, cordate to auriculate at the base.

Underleaves inflated, the yellow-brown margins appressed to the stem; leaf cells mostly 18–22 μ ..... 24. *B. jamaicensis*

Underleaves plane, the margins rarely pigmented, cells of the apical part elongated and with knot-like in-

termediate thickenings on the walls; leaf cells mostly 24 μ or more in diameter ..... 25. *B. wrightii*

Underleaves oval, the base rounded to cordate.

The apical margin of the underleaves retuse, the lateral margins recurved. ..... 18. *B. acuminata*

The apical margin of the underleaves entire or sinuate but not retuse.

Leaves strongly arcuate, the ventral margin deeply concave from a large rectangular auricle ..... 25a. *B. arcuata*

Leaves spreading to arcuate, but not as above.

Cells of the apical part of the underleaves elonate and with intermediate thickenings on the walls; leaf cells mostly 24 μ or more ..... 25. *B. wrightii*

Cells of the apical part of the underleaf quadrate (the walls often somewhat thickened and pigmented); leaf cells mostly 18–22 μ ..... 24. *B. jamaicensis*

8. BAZZANIA AFFINIS (L. & G.) Trevis.

add syn. *Mastigobryum lindigii* Stephani, Hedw. **25**: 203. pl. 3. f. 44–45. 1886. syn. nov.

BAZZANIA LINDIGII Spruce, Mem. Torrey Club **1**: 129. 1890. syn. nov.

Mastigobryum lindigii was incorrectly reduced to synonomy under *B. stolonifera* (see Fulford, 1946, p. 44) on the basis of the hyaline border of the underleaves. It was noted at that time that the walls of the leaf cells were thin, with very small trigones. The cells of the upper part of the leaf of *B. stolonifera* are 25 (or more)×21 μ, usually with conspicuous trigones, while the cells of the leaf of *M. lindigii* are smaller, mostly 18×18 μ with thin walls and scarcely developed trigones.

Habitat: On trees, decaying logs and stones in forests.
Distribution: Mexico: add, Teotalcingo, Liebmann, the original (FH, G); Chinantla, Liebmann, as *β. dentibus minoribus* (G).—Guatemala: Pitoreal, Sharp 2771b (Tenn).—Colombia: add, without locality, Lindig, original of *M. Lindigii* (G); Cordillera La. Macarena, Cano Teranas, 1700 m., Schultes 11258 (FH).—Ecuador.—Peru.—Bolivia: add, Yungas, 6000, Rusby 3023, as *B. lindigii* (G).

9. BAZZANIA PALLIDE-IRENS (Steph.) Fulford. Figures 12–15.

This luxurious species occurs in the mountains of Peru, Ecuador, Brazil, Colombia and Venezuela. The plants are large and the teeth of the spreading or falcate leaves are usually sharp and conspicuous, but there is considerable variation even on one stem. Four-toothed leaves are quite common on some plants. The underleaves vary to the extent that those of some of the branches are totally different from those of the main axis. The underleaves of the stems are large, quadrate to elongate, with the apex irregularly and sparingly short spinose to irregularly incised (figs. 12, 13). On the older stems they are chlorophyllose throughout, or hyaline in the upper one or two rows or to the middle. The underleaves of some of the smaller young branches tend

to be broadly oval to quadrate, hyaline throughout, and the cells are more elongate with the margin distinctly crenulate.

Female branches were not uncommon but no perianths were found. The female bracts and bracteoles are large and the intermediate and innermost series are long lacinate-ciliate (figs. 14, 15).

Habitat: On bark, tree roots and moist cliff faces in the montane rain forest.
Distribution: Colombia: Rio Piraparana, Schultes & Cabrera 17273 (FH); Rio Apaporis, Schultes & Cabrera 12548, 12550 (FH); Rio Kananari, Schultes & Cabrera 13112 (FH); Rio Uaupes, Mitu, Schultes & Cabrera 13857 (FH); Rio Miritiparana, Schultes & Cabrera 16542, 16554 (FH); Rio Kuduyari, Schultes & Cabrera 17909 (FH); Rio Paca, Schultes & Cabrera 19509; Rio Papuri, Schultes & Cabrera 19455 (FH); Yapoboda, Schultes & Cabrera 14300 (FH); Dept. del Valle, Bahia de Buena Ventura, Cuatrecasas 19993-B (US).—Venezuela: Cerro Yapacana, Maguire, Cowan & Wurdack 30609 (NY); Cerro Huachamacari, Maguire, Cowan & Wurdack 29925 (NY); Camp Cano, Cowan & Wurdack 31275 (NY); Serrania Parú, Cowan & Wurdack 31428 (NY).—Brazil: add, without locality, Glaziou 14418, the original (FH, G); Manáos and San Carlos, Spruce, *Hep. Spruc.* as *B. bidens* var. (NY); the same, under *B. brasiliensis*, n. var. (NY); Rio de Janeiro, Glaziou 14418, as *M. wrightii* (NY).—Ecuador; Mt. Chimborazo, Spruce, *Hep. Spruc.*, with *B. trichoidea*, no. 371 (NY).—Peru: Tarana, Spruce, *Hep. Spruc.*, under *B. wrightii* (NY).

10. BAZZANIA STOLONIFERA (Sw.) Trevis, Figure 16.
add syn. *Mastigobryum azuayense* Stephani, Spec. Hep. **6**: 454. 1924. syn. nov.
[Stephani, Icones, Hep., *Mastigobryum*, no. 152/53.]

The original material of *M. azuayense* from Ecuador is no different from *B. stolonifera*. This abundant and widespread species shows a high degree of variability but can be readily recognized by its more or less large, quadrate underleaves with a hyaline border two to many cells in width. This band of thin-walled hyaline cells without trigones surrounds the chlorophyllose area of cells with conspicuous trigones. The leaf cells are 25 (or more) × 21 μ, and the trigones are usually well-developed. *M. lindigii*, which was incorrectly reduced to synonomy under this species earlier (Fulford 1946), is a synonym of *B. affinis*, since the plants are small, most of the underleaf is hyaline and the leaf cells are only 18 × 18 μ, with indistinct trigones.

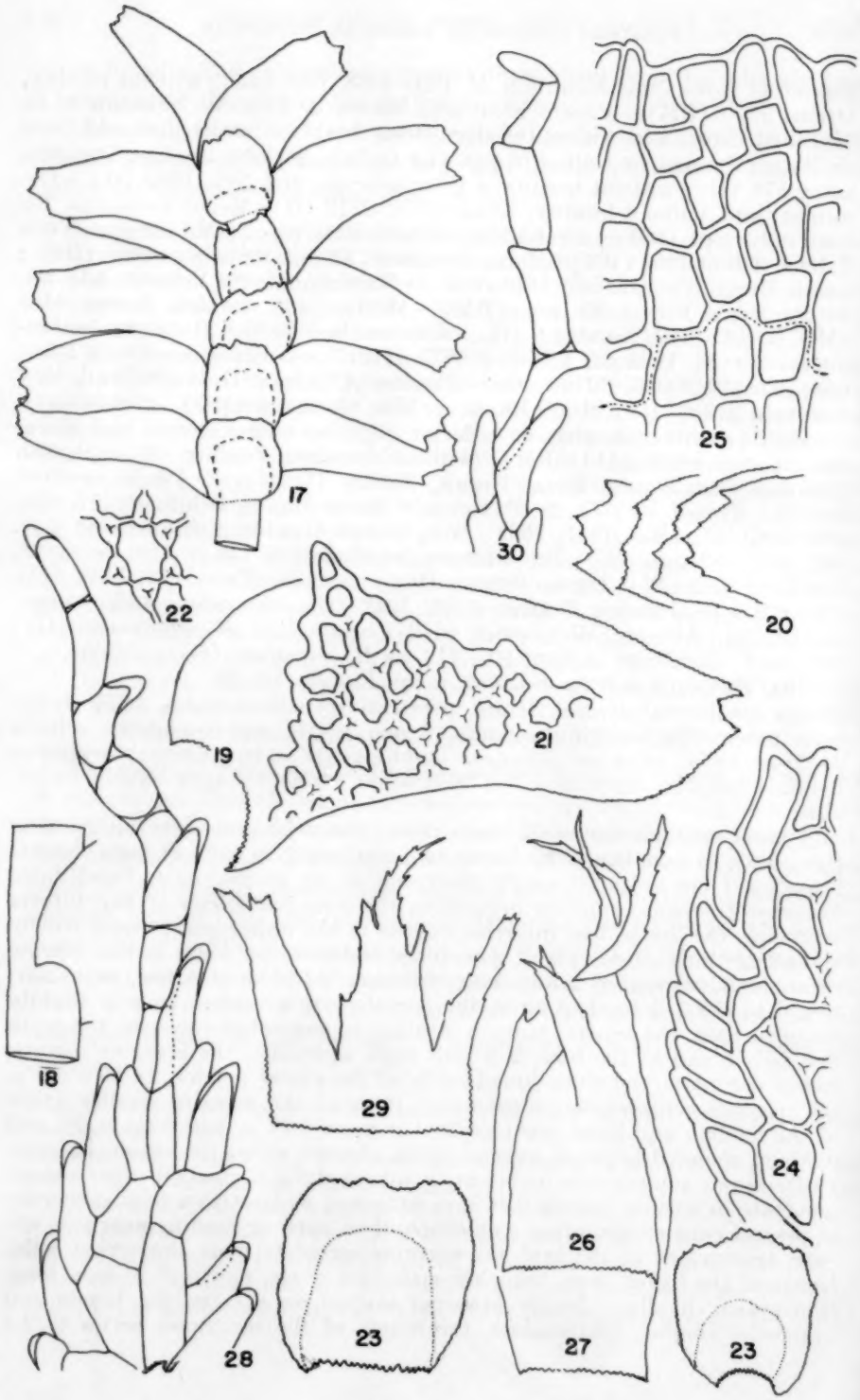
Habitat: In deep tufts or mats or mixed with other bryophytes, on soil, logs and trees in forests.
Distribution: Cuba: add, Oriente, Sierra Meistra, Morton 9544 p.p., 9545 p.p. (US); Santiago de Cuba, Linden 2197 (G).—Jamaica: (original B, NY, FH) add, Bellevue, Lewis 87, 94 (IJ); Sir John's Peak, Lewis 96 (IJ); Hardware Gap, Baxter 30 p.p. (KANU); Hardware Gap to waterfall, Porter 358 (IJ); the same, Baxter 62 (KANU); n'r Cinchona, Porter 436 (IJ); Fairy Glade, M. Farr 533, 781 p.p. (IJ); Caledonia Peak, M. Farr 1010 p.p. (IJ); sw. of Eccelesdown, M. Farr 1143 (IJ); the same, O'Regan 1476 (IJ);

summit of Cuna Cuna Mountain, M. Farr 1388, 1391 (IJ); without locality, Orcutt 5220 (BM).—Puerto Rico: add, Sierra de Luquillo, Sintenis H 16 (G).—St. Kitts: add, without locality, Breutel (G).—Guadeloupe; add, forêt de Baines Jaunes, Le Gallo 676 p.p. (Le Gallo); without locality, Durchessaing 576 (G); without locality, l'Herminier 55, 160, 561, 1005 (G).—Dominica: add, without locality, Elliott 1020, 2212 (G); Morne Cousonne, Elliott 201a p.p. (BM); n'r Laudat, Elliott 502a p.p. (BM); Morne Trois Pitons, Elliott 729c (BM); Morne Diablotin, Elliott 1060a p.p. 1068 (BM); Castle Bruce River, Elliott 1618 (BM).—Martinique.—St. Vincent: add, Mt. St. Andrews, Elliott 80c p.p. (BM).—Mexico: add, Oaxaca, Santos 3486 (MICH); Capital, Karsten 9 (G).—Guatemala.—British Honduras.—Honduras: n'r El Achnote, Yuncker 6613 (DPU).—Nicaragua.—Costa Rico: add, Brushik, 300m., Pittier (G).—Panama: Chirique, Holcomb Trail, Mrs. Cornman 3139, 3158 (MO); Chirique, Mrs. Cornman (MO).—Colombia.—Venezuela; without locality or collector (G); between Valencia and Maracay, Alston 6148, 6149 (BM); without locality, Fendler (G).—British Guiana.—Brazil: add, Minas Gerais, Wainio 17 (G); S. Paulo: without locality, Kroner 10 (G); S. Paulo: n'r Barra Mansa, Schiffner 357. 358, 498, 506, 507, 1808, 1847, 2062 (W); Campo Grande, Schiffner 463 p.p., 466, 467, 479 p.p. (W); Rio Grande, Schiffner 798 (W); Alto de Serra, Schiffner 1083 (W); Brasso Grande Itapecirica, Schiffner 1317, 1405, 1714 (W); Rio de Janeiro, Graziou 4572, 1212 (G).—Ecuador: add, Azuay: Gualaquiza, Allioni (Hb. Levier 6570), original of *M. azuayense* (G); Oriente-V. Bomboiza, Allioni 601, 713, as *M. arcuatum* (G).—Bolivia.

10a. **Bazzania serrata** Fulford, n. sp. Figures 17–30.

Caules mediocres, olivacei-virides, prostrati vel adscendentes, foliis imbricatis patentibus, marginis serratis, 2 mm longis, uni-tridentatis, cellulis 24–27 $\mu \times 18$ μ, trigones insignes: amphigastria subquadrata marginibus hyalinis serratis: bracteae ♀ 3–4 laciniatae: perianthii apex longus, laciniatus.

Plants medium size, dull olive green, yellowish-green at the growing tips: stems to 4 cm long, with leaves to 3 mm broad, in tufts or mats; lateral branches 1 cm or more apart, diverging at an acute angle, flagelliform branches frequent; rhizoids present on the scale-like leaves of flagelliform branches: the line of leaf insertion curved in the upper part; leaves widely spreading, imbricated, plane, sometimes caducous on older stems, serrate throughout, averaging 2 mm. long, 0.6 mm. broad at the base, little narrowed to the 1–3 toothed apex, the dorsal margin convex from a slightly rounded base, the ventral margin straight to somewhat concave; the teeth 3–6 cells broad at the base, 2–5 cells high, apiculate, the margins serrate, rarely crenulate, the sinus broad; cells of the apical portion 24–27 $\mu \times 18$ μ, the trigones conspicuous or coalesced, those of the margins smaller, those of the median and basal portions 36 (or more)$\times 27$ μ, with thin walls and distinct, rounded trigones, suggesting an obscure vitta; the cuticle coarsely verruculose: underleaves imbricated, attached in a straight line, round-quadrate in outline, mostly 0.46 mm. long and wide, with a hyaline border of several rows surrounding a chlorophyllose part, or hyaline nearly to the base, trigones as in the leaf, the margins serrulate from projecting cells; leaves of the flagelliform branches scale-like, ovate, mostly 0.16 mm. long, thin-walled, hyaline; female branches several on a stem, the bracts and bracteoles similar, oblanceolate, the bracts of the innermost series to 2.4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mm. long (immature), to one-third divided into three or four long, narrow crenate lacineae: the perianth about 5 mm. long, ovoid-cylindrical, 3-keeled in the median part, contracted to the long-laciniate mouth.

The distinguishing characteristics are the spreading, entire to trifid leaves, serrate all around, and the quadrate, serrulate underleaves with a border of hyaline cells, or hyaline except at the base.

The serrate margins of the leaf and the serrulate, hyaline margins of the underleaves (figs. 17, 19–21, 23) suggest a relationship with members of the Section *Connatae*, namely *B. pycnophylla*, *B. eggersiana* or even *B. aramtistipula*, but the underleaves are not connate with the leaves, a character of all members of the Connatae. The hyaline border of the underleaves (figs. 17, 23, 25) of well developed stems is similar to that in the underleaves of *B. stolonifera*, but in the latter species, the leaf margins are never serrate and the three teeth are usually more distinct. *B. serrata* differs from *B. affinis*, which also has hyaline underleaves, in that, in the latter, the leaf margins and the teeth are never serrate and the cells are smaller, only 20 μ or less and without conspicuous trigones.

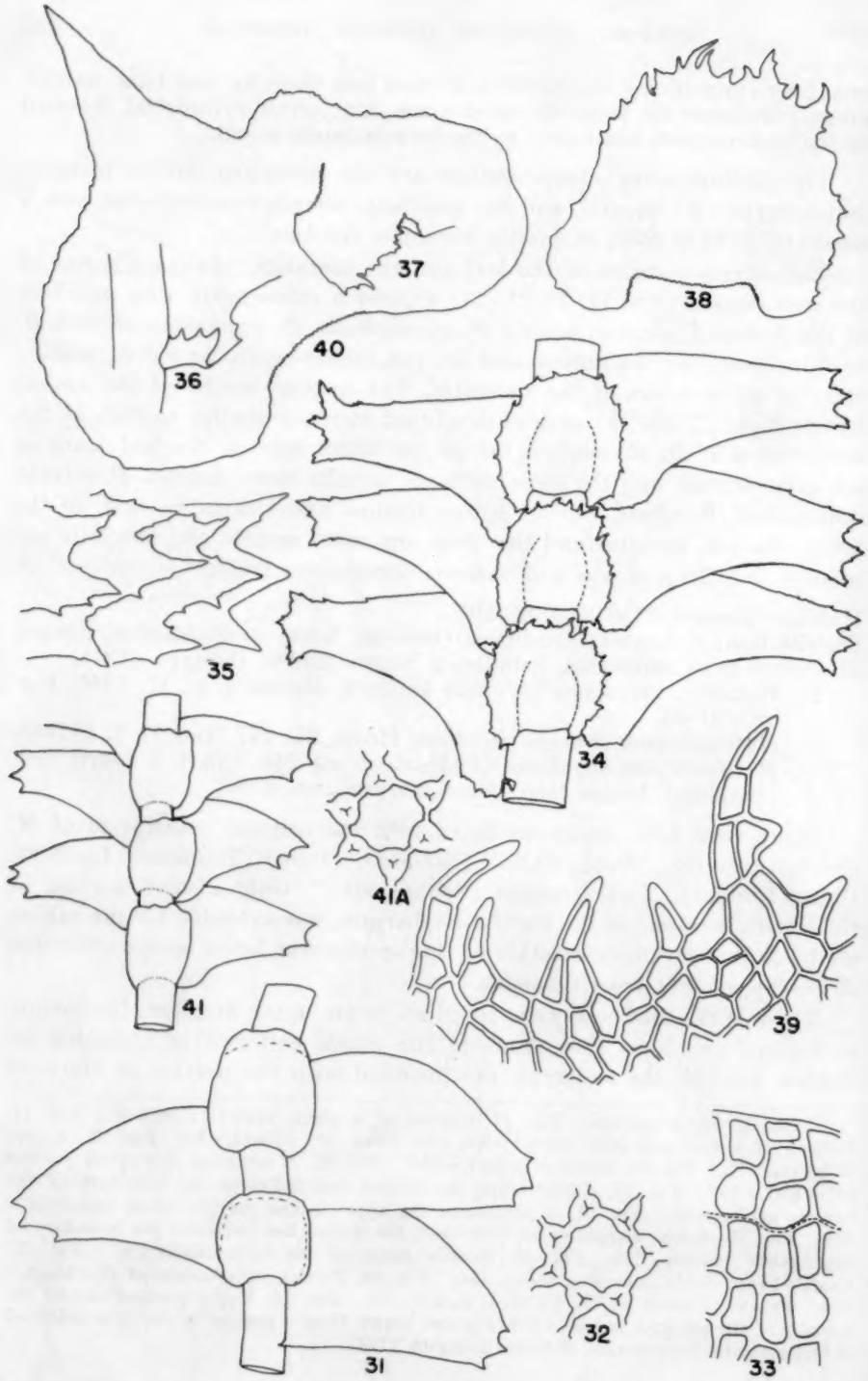
Habitat: Forests, 2150–2230 m. alt.
Distribution: Colombia: Cordillera Oriental, Norte de Santander, Sarare, 2150–2250 m., Cuatrecasas, Schultes & Smith 12448z, the type (US).

11. Bazzania chilensis (Steph.) Fulford, *Bazzania*, p. 51. 1946. Figures 31–33.
Mastigobryum chilense Stephani, Hedw. **24**: 247. Tab. II. f. 1. 1885.
Mastigobryum bogotense Stephani, op. cit. 246. Tab. I. f. 1. syn. nov. [Stephani, Icones Hep., *Mastigobryum*, no. 376a].

There were four specimens listed with the original description of *M. chilense*, namely, "Peru, Callao (Nöllner), [Peru], Talarana (Lechler), Chile (Lechler), Nova Granada (Schlim 861)". Only a small portion of the latter collection, in the Farlow Herbarium, was available for the earlier study, so that my interpretation of this species was based on the collection of Schlim, no. 861 from Colombia.

Three of the four collections listed above are in the Stephani Herbarium at Geneva and have been studied. The plants collected in Colombia by Schlim, no. 861, the lectotype, are identical with the portion at Harvard

Figs. 17–30. *B. serrata*. Fig. 17. Portion of a plant, ventral view, × 30. Fig. 18. Portion of a leaf and stem dorsal view, × 75. Fig. 19. A leaf, × 80. Fig. 20. Apices of leaves, × 80. Fig. 21. Tooth of a leaf, × 350. Fig. 22. A cell from the apical portion of a leaf, × 350. Fig. 23. Underleaves, the dotted line indicates the boundary of the hyaline border, × 80. Fig. 24. A portion of the upper lateral margin of an underleaf, × 350. Fig. 25. Apical margin of an underleaf, the dotted line indicates the boundary of the hyaline border, × 350. Fig. 26. Female bract of the outer series, × 80. Fig. 27. Female bract of the innermost series, × 80. Fig. 28. Portion of a lacinia of this bract, × 350. Fig. 29. Portion of the perianth mouth, × 80. Fig. 30. Upper part of one of the laciniae of the perianth mouth, × 350. Figures drawn from a portion of the type collected in Colombia by Cuatrecasas, Schultes & Smith (US).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which I had used earlier. Those collected by Lechler, no. 13 in Chile are similar, but the original published illustration and the drawing of "*M. chilense* St., n. sp., Chile, leg. Lechler" in the Icones, *Mastigobryum* no. 381, do not agree with the plants of this collection. The plant (one stem) from Talarana, Peru, also collected by Lechler, no. 1850a, is very similar but is larger and the underleaves do not have the hyaline border. The plants from "Peru, Callao (Nöllner)" were not seen.

The species, *M. bogotense* Stephani, was described from plants collected by Lindig in Bogota. These plants (fig. 31) are like those of *B. chilensis*. The stems are similar in appearance, the leaf cells are mostly 18–20 μ, the trigones are small and the cuticle is strongly verruculose. The underleaves also agree with this species in size and shape and have the distinguishing border of one-two rows of hyaline cells with trigones.

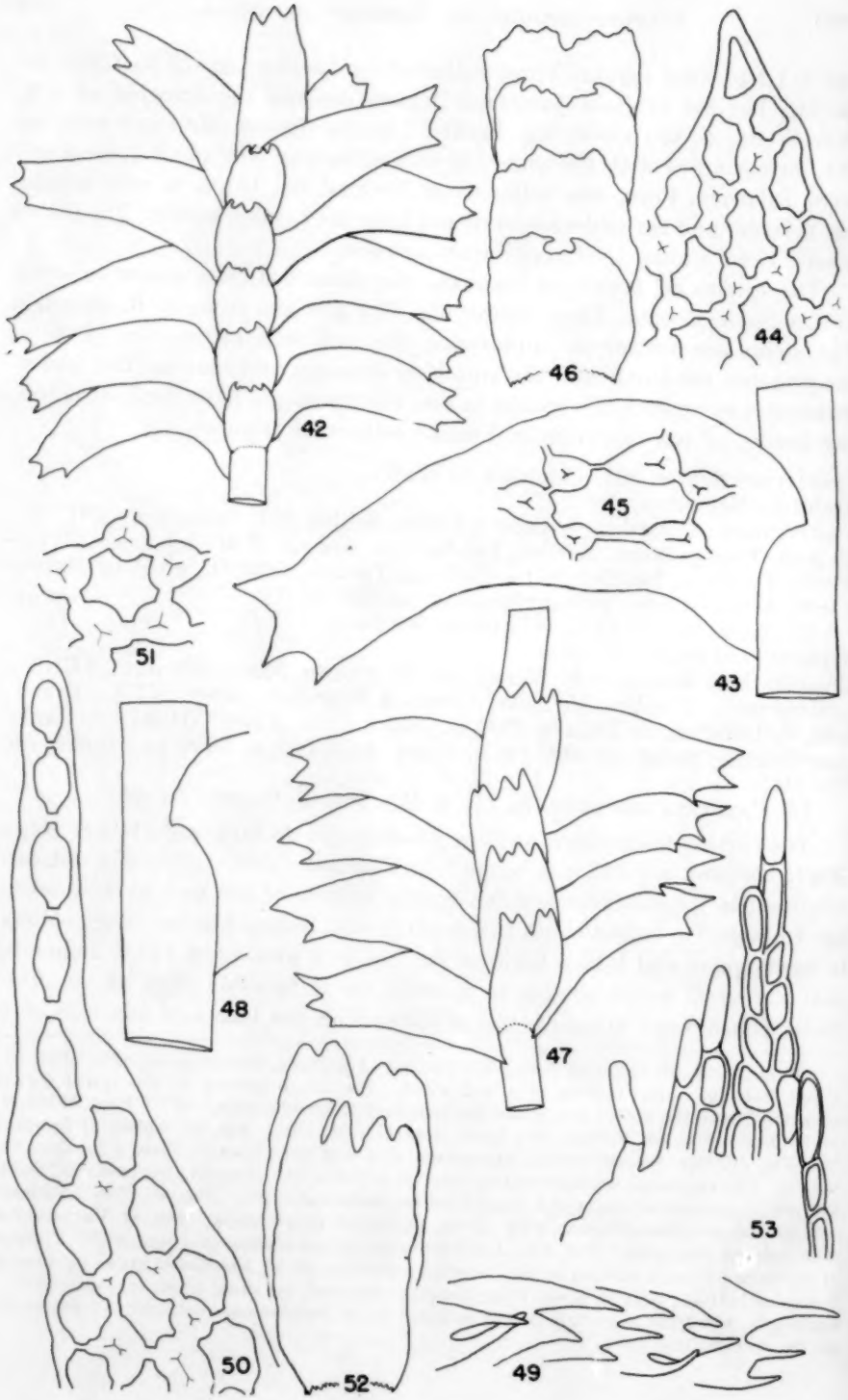
Lectotype: Schlim 861, Colombia (FH, G).
Habitat: Not given.
Distribution: Colombia: without locality, Schlim 861, Lectotype (FH, G); Bogota, Tequandanea, 2500 m., Lindig, the original of *M. bogotense* (G).—Peru: Talanara, Lechler (G).—Bolivia: Yungas, 6000 ft., cited by Spruce (1890, 129).—Chile: without locality, Lechler 13 (G).

12. Bazzania taleana (Gottsche) Fulford.
Habitat: On trunks of trees.
Distribution: Mexico: add, Vera Cruz, El Puerto, Sharp 641 p.p. (TENN).—Venezuela: Cumbre, McGuire, Cowan & Wurdack 30698 (NY).—Brazil: add, S. Catarina de Padres, 1900 m., Reitz 2.566, 2.604 (HBR); S. Paulo, Rio Grande, Schiffner 684 (W); Serra do Itatiaya, 2100 m., Dusén 50, 387 (G).

13. Bazzania denticulata (L. & G.) Trevis. Figures 34–40.

The earlier descriptions and the illustrations by Stephani (Icones Hep., *Mastigobryum*, no. 345 a & b) and by Fulford (1946, f. 17) did not call attention to the characters of the ventral auricle of the leaf on well-developed plants. On robust stems this ventral auricle may become large, oblong to rectangular and folded back on the leaf to a greater or lesser degree so that a ventral pouch similar to a water sac is formed. (figs. 34, 36, 37). These pouches are always better developed on the leaves of one side of a

Figs. 31–33. *B. chilensis*. Fig. 31. Portion of a plant, ventral view, × 30. Fig. 32. A cell from the apical portion of a leaf, × 360. Fig. 33. A portion of the apical region of an underleaf, the dotted line marks the boundary of hyaline cells, × 350. Figs. 34–40. *B. denticulata*. Fig. 34. Portion of a plant, ventral view, × 15. Fig. 35. Apices of leaves, × 38. Fig. 36. The dentate ventral appendage of a leaf bent back to form a lobule, × 38. Fig. 37. The expanded dentate ventral lobe of a leaf, × 38. Fig. 38. An underleaf, × 38. Fig. 39. A portion of the upper margin of an underleaf, × 180. Fig. 40. The 'half-leaf' formed with the lateral branch, × 38. Figs. 41, 41a. *B. longistipula*. Fig. 41. Portion of a stem, ventral view, × 30. Fig. 41a. A cell from the apical portion of a leaf, × 350. Figures 31–33 drawn from a portion of the original collection of *M. bogotensis* made by Lindig in Colombia (G); figures 34–40 from material collected by Bues, 1160, in Peru (NY); figures 41, 41a from a portion of the original of *M. columbicum* collected by Irmscher, no. 29, in Colombia (G).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stem and may even be absent on the leaves of the other side. The margin of this auricle may be entire or crenulate to obscurely spinose, as in the plants from Jamaica, or it may be strongly spinose, as in the plants collected by Bues, no. 1160, Department of Cuzco, Peru. (figs. 36, 37). This pouch (fig. 36) is a striking character of the plant and is not present in any other species of *Bazzania* from the American tropics.

In leaves without ventral pouches, the teeth of the leaves tend to be entire; when auricles or pouches are developed to some extent, the margins of the teeth and the upper margins of the leaves have scattered projections, but where the spinose pouches are conspicuously developed, the upper margins of the leaves are spinose-toothed (fig. 34) and the margins of the teeth are coarsely spinose (fig. 35). Since both sorts of plants occur in widely separate areas, Jamaica and Peru, and since all gradations occur, it would seem that this is another species with a wide degree of variation. In this instance there appears to be no closely related species in the Americas.

Habitat: Over mosses, tree bases and logs, in montane forests.
Distribution: Jamaica: add, without locality, Sherring 7 (BM).—Mexico: (original G).—Brazil: Caraça, Wainio 46 p.p. (G).—Bolivia.—Peru: St. Gavan, Lechler (G); Cuzco: La Convencion, 1800 m., Bues 1160 (NY).

14. BAZZANIA QUADRICRENATA (Gottsche) Pagán.
add. syn. *Mastigobryum martianum* Lindberg (nomen nudum)
Non *Mastigobryum martianum* Gottsche, *In* Stephani, Hedw. **25**: 205. 1886.

The name *M. martianum* Gottsche, was incorrectly reduced to synonomy under *B. quadricrenata* (Fulford, 1946, p. 60) on the basis of the material collected by Lindberg in Caldas, Brazil. That material does belong to the latter species but it is quite different from the original material of *M. martianum*, "leg. Martius, Brasilia, ex hb. Gottsche" now at Geneva. These plants have large, cordate underleaves which are entire or nearly so, falcate leaves with distinct auricles, and leaf cells with thin walls and distinct, rounded trigones. *M. martianum* Gott. is a synonym of *M. arcuatum* described under No. 25a.

There is considerable variation in *B. quadricrenata*, particularly in the shape of the underleaves which are 4-lobed, broadest above the middle, with bulging, lobed to incised lateral margins. Even on those stems where

FIGS. 42–46. *B. sublonga*. FIG. 42. Portion of plant, ventral view, × 15. FIG. 43. Portion of a stem and a leaf, × 40. FIG. 44. A tooth of a leaf, × 390. FIG. 45. A cell from the apical portion of a leaf, × 390. FIG. 46. Apices of underleaves, × 40. FIGS. 47–53. *B. elongata*. FIG. 47. Portion of a plant, ventral view, × 15. FIG. 48. Portion of a plant, dorsal view, × 40. FIG. 49. Apices of leaves, × 40. FIG. 50. A tooth of a leaf, × 350. FIG. 51. A cell from the apical portion of a leaf, × 350. FIG. 52. Underleaves, × 40. FIG. 53. Portion of a female bract of the intermediate series, × 166. Figures 42–46 drawn from the type collected in Jamaica by M. Farr 1378 (IJ); figures 47–53 drawn from the type collected in Venezuela by Steyermark 75787 (NY).

most of the underleaves are only slightly four-lobed, the underleaf at a lateral branch or one subtending a flagelliform branch is usually more deeply cut. The leaf cells are mostly 20–24 μ.

Habitat: On trees in forests.
Distribution: Jamaica: add, Fairy Glade, M. Farr 774 (IJ); summit of High Peak, M. Farr 907, 911 p.p., 914 (IJ); slope of Mossman's Peak, M. Farr 728, 729, 747 (IJ); New Haven Gap, M. Farr 928 p.p. (IJ); slope of Mt. Horeb, M. Farr 950 (IJ).—Puerto Rico: without locality, Pagán 283 (NY).—Guadeloupe: (original, G).—Guatemala: Pitoreal, Sharp 2776b, 2781 (TENN).—Trinidad: Long Stretch, Broadway 6872 (BM).—Colombia: Rio Uaupes, Schultes & Cabrera 13856 (FH); Rio Apaporis, Raudal Yayacape, Schultes, Cabrera & Bell 15441 (FH).—Brazil: Caldas, G. A. Lindberg (original of *M. martianum* Ldbg. and f. *paupercula* Ldbg.) (NY).—Venezuela.

14a. MASTIGOBRYUM MARTIANUM, Gottsche, *In* Stephani = ***B. arcuata*** (L. & G.).—No. 25a.

15. BAZZANIA AURESCENS Spruce.

The original material from Peru has leaves with long, crenulate teeth, and cells of the upper portion of the leaf 24–36 μ long with large, knot-like trigones. Other plants of the same general habit may have shorter teeth on the leaves.

Habitat: On shady rocky slopes, logs and tree trunks, at higher altitudes.
Distribution: Colombia: Rio Apaporis, Schultes & Cabrera 12552, 16582 (FH); Rio Coqueta, La Pedrera, Schultes, Cabrera & Bell 17816 (FH).—Venezuela: add, Hacienda Cura (n'r Valencia), Alston 6143 (BM); Playa Alta, Maguire, Cowan & Wurdack 29398 (NY).—British Guiana: Bartica, Tutin 223 (BM).—Ecuador: V. Bomboiza, Gualaquiza, Allioni 353 *Bryo. Ecuador*, Allioni (G).—Brazil: Apiahy, Puiggari 108, as *M. scutigerum*, 761, as *M. arcuatum* (G); S. Paulo, Campo Grande, Schiffner 459 (W); Alto da Serra, Schiffner 1063 (W); n'r Santos, Schiffner 1056 (W).— Peru: (original, FH, G).

16. BAZZANIA GLAZIOVII (Gottsche) Fulford.
Habitat: Over rocks.
Distribution: Colombia: Rio Kuduyai, Schultes, Cabrera & Bell 14302 (FH); Rio Piraparana, Schultes, Cabrera & Bell 15899 (FH).—Brazil: (original, FH, G); add, Quimado, de Rossmalen 277 (G); S. Paulo, n'r Rais de Serra, Schiffner 930 (W); Apiahy, Schiffner 2319 (W).

17. BAZZANIA BREUTELIANA (L. & G.) Trevis.

The species ***B. chimborazensis*** Spruce, was erroneously reduced to synonomy under ***B. breuteliana*** (Fulford, 1946). It is a good species and will be discussed under No. 17a.

The widespread species, ***B. breuteliana*** shows considerable variation in size, form of the leaf apices, and the configuration of the underleaves. When characteristically developed, the species is readily recognized because of its large size and olive green color, the large spreading leaves with broad apices, with three nearly equal teeth and cells mostly 20×20 μ. The underleaves are

large, quadrate to oblong, rounded to cordate at the base and rounded-entire to characteristically four-lobed at the apex. They are two to three times as broad as the stem.

The less robust plants are confusing. If the leaves tend to be somewhat ascendant and the underleaves narrow, the plants suggest *B. longistipula;* if the leaves tend to be narrow at the apex and more or less recurved and the underleaves are narrow, the plants suggest *B. wrightii* or *B. arcuata;* and if the plants are very small they suggest *B. chilensis* and *B. taleana.* The cell size and other diagnostic characters as listed in the Key will serve to separate the various species.

Habitat: On logs, tree bases and branches, in wooded areas.
Distribution: Cuba:—Jamaica: add, Morce's Gap, Bengry (IJ); summit of Sugar Loaf Peak, M. Farr 1092 (IJ).—Puerto Rico: add, n'r Adjuntas, Sintenis H87, H92 (G); n'r Naguabo, Sintenis H3, H123 (G); Sierra de Luquillo, Sintenis H18, H33 (G); without locality, Schwanecke 23, 728, 1161 (G).—St. Kitts: (original, NY, G); add, Mt. Misery, without collector, no. 275 (G).—Guadeloupe: add, without locality, l'Herminier, as *M. silvaticum* (G); without locality, l'Herminier 114 (G).—Dominica: add, without locality, Eggers 54 (G); sylva ad Laudat, Eggers (G); without locality, Elliott 1108, 1611, 1643 (G); Morne Anglais, Elliott 487f (BM); Morne Diablotin, Elliott 690c p.p., 1009c p.p., 2146, 2212 (BM); Morne Trois Pitons, Elliott 2279, 2315 (BM); summit of Couliabon, Elliott 1894a (BM); Roseau Lake, Elliott 1167 (BM).—Martinque: add, without locality, Duss 205 (G).—Trinidad: Mt. Aripo, Greig-Smith 1450 (IJ).—Mexico: add, Oaxaca, Sharp 5702 (TENN.)—Guatemala: Nepaj, Sharp 2529 (TENN).—Costa Rica: add, forêt du Rio Narango, Tonduz 15621 (G); Alto del Pito: Mt. San Marcas de Dotam, 1400 m., Tonduz 3009 (G).—Colombia: Prov. Antiguia, Wallis, as *M. bogotense* (G); Rio Kananari, Schultes & Cabrera 13117 (FH); Villaricencio, Alston 7583 (BM); Noter de Santander, Cuatrecasas Schultes & Smith 12448t (US); Dept. del Valle, Cuatrecasas 14951-B (US).—Venezuela: n'r Maturin, Alston 5583 (BM); Estado Bolivar, Chimanta Massif, Steyermark 75578 (NY).—British Guiana.—French Guiana: without locality, Leprieur 292, as *M. stoloniferum* (G); Cayenne, Perrottet, as *M. stoloniferum* (G).—Ecuador: Gualaquiza, Allioni (hb. Levier 6574, 6575) as *M. lindigii* (G); Oriente-V. Bomboiza, Allioni 343, as *M. cuervii* (G).—Brazil: add, without locality, Sellow, as *M. martianum* (G); Catarina, Reitz 2.137a, 2.566 (HBR); without locality, Ule 327, as *M. lindigii* (G); S. Paulo; Alto de Serra, Schiffner 1064 (W); Brasso Grande, Schiffner 1313, 1547 (W); without locality, leg. Jack, as *M. brasiliense* (G); Petropolis, Döring (G).—Peru: add, Tanatara, Lechler, as *M. chilense* and *M. scutigerum β. lechleri* (G).—Bolivia: Yungas, Tröll 89 (Hb. Herzog).

17a. BAZZANIA CHIMBORAZENSIS Spruce. Trans. & Proc. Bot. Soc. [Edinburgh] **15**: 376. 1885. Figures 63–66.
Mastigobryum chimborazensis Stephani, Spec. Hep. **3**: 527. 1909. [Erroneously reduced to synonomy under *B. breuteliana,* Fulford 1946, p. 68].

Plants robust, in tufts on branches of trees, yellow-green becoming olive-green to brown: stems to 10 cm. or more long, and, with leaves, 4–5

mm. broad; lateral branches infrequent: rhizoids abundant from bases of scale leaves of the flagelliform branches: the line of leaf insertion curved in its upper part, the dorsal margin recurved forming a hook: the leaves imbricated, plane to deflexed, unsymmetrical, oblong ovate, spreading and a little decurved, averaging 2.25 mm. long, to 1.6 mm. broad at the base, narrowed a little to the more or less obliquely truncate, irregularly 3-toothed or occasionally 4-toothed apex; the dorsal margin arched from a strongly rounded base, extending across the stem and beyond, the ventral margin slightly to conspicuously concave, the ventral base more or less dilated; the teeth mostly large, acute, 3 to 8 cells long, 3 to 8 cells broad at the base, the sinuses acute, the margins more or less serrate; leaf cells quadrate to longer than broad, the walls thin, the trigones small with convex sides sometimes coalesced, the cuticle verruculose; cells of the apical portion $18–22 \times 18\mu$, those of the median and basal portions larger: underleaves imbricated, large, quadrate, much broader than the stem, averaging 1 mm. long and broad, attached in a straight or slightly curved line, the base rounded to subcordate, the lateral margins convex, sinuate with broad lobes, the apex lobed and toothed, very often with some cells of the margin hyaline, the cells as in the leaf. Male and female inflorescences and sporophyte not seen.

The distinguishing characteristics of the species are, its very robust habit, the large, more or less decurved leaves with large, obscurely serrate teeth, and the thin-walled cells with small trigones; the large, quadrate underleaves, rounded to subcordate at the base, sinuate to lobed on the lateral margins and irregularly lobed and toothed at the apices; and the scattered hyaline marginal cells of the underleaves.

The species was erroneously placed in synonomy under *B. breuteliana* because large plants collected by Spruce on Mt. Chimborazo, distributed in *Hepaticae Spruceana,* agreed with that species. Other packets with this same label, from Geneva, contain plants which agree with the original description of *B. chimborazensis* and the Stephani drawings in the Icones, *Mastigobryum,* no. 382.

B. chimborazensis is readily separated from *B. breuteliana* (the robust *B. viridissima* of Spruce from the same general locality), by characters of its underleaves which, in the former species, are sinuate and lobed along the lateral margins, irregularly toothed and lobed at the apex, and have a few scattered hyaline marginal cells. The margins of the teeth of the leaves are serrate to some degree, while in *B. breuteliana*, the margins of the teeth are entire.

Habitat: On tree trunks, branches and logs.
Distribution: Costa Rica: cited by Herzog (1938, 19).—Colombia: Dept. del Valle, Rio Cajambre, Cuatrecasas 17024-B, 17059-B (US).— Brazil: Manáos, Spruce, Hep. Spruc., as *B. brasiliensis* (NY); S. Paulo: Itapecirica, Brasso Grande, Schiffner 1320 (W); Minas Gerais, Caldas, Mosén (G).— Ecuador: Andes Quitensis, Mt. Chimborazo, 1300 m., Spruce, *Hep. Spruc.* [no. 113], the original (G); another packet, Andes Quitensis, Chimborazo, Spruce (G).

18. BAZZANIA ACUMINATA (L. & G.) Trevis.
Habitat: Not given.
Distribution: Mexico: (original, G); Chiapas, Mapastipec, Sharp 4558 (TENN).—Venezuela.

19. BAZZANIA DIVERSICUSPIS Spruce.
add syn. *Mastigobryum venezuelanum* Stephani, Spec. Hep. **3**: 530. 1909. Non *M. venezulanum* Molk. *in* Sande Lac. syn. nov.
[Stephani, Icones Hep. *Mastigobryum,* no. 404.]

This species is the size and general aspect of *B. affinis* and differs from it in that the underleaves are not hyaline except for occasional scattered marginal cells, trigones are conspicuous and the cells are larger.

Habitat: Depressed mats among ferns.
Distribution: Trinidad.—Brazil: (original, NY, G).—Venezuela, Fendler, original of *M. venezuelanum* (G).

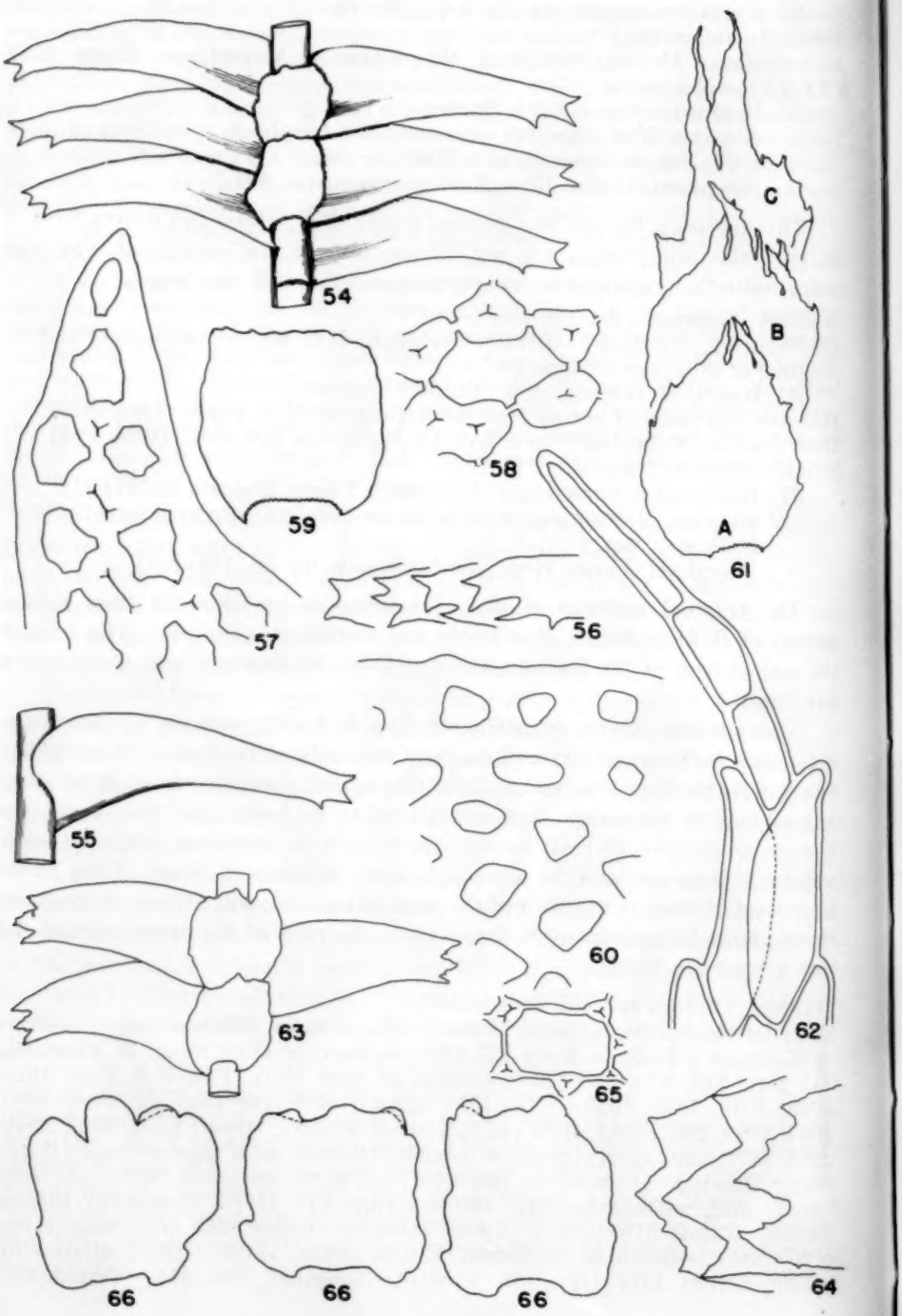
20. BAZZANIA TRICUSPIDATA (Steph.) Fulford.
Habitat: On bark of rotten logs, dark gorge of Mist Forest (Schultes).
Distribution: Colombia: Cordillera La Macárena, Schultes, 11254 (FH).—British Guiana: (original, FH, G).

21. BAZZANIA LONGISTIPULA (Lindenb.) Trevis. Figures 41, 41a.
add syn. *Mastigobryum colombicum* Stephani, Spec. Hep. **6**: p. 458. 1924. syn. nov.
[Stephani, Icones Hep., *Mastigobryum* no. 26, 154/155]

The original material of *M. columbicum* is no different from robust plants of *B. longistipula.* The leaves are ascendant, (Fig. 41). The cells of the apical part of the leaf are mostly 24–27μ in diameter and the trigones are large.

This species, of very wide distribution, is highly variable in size, form, color, cell pattern and size and shape of the teeth of the leaves. Many of the variant forms have received specific names and there are a dozen or more names now in synonomy. The stems tend to be brown and the leaves are always ascendant, at least in the upper part of the stem, with the apex obliquely truncate, and the acroscopic tooth the longest. Some of the leaves may tend to become falcate but the smaller cell size will at once distinguish these plants from those of *B. longa* where the cells of the upper part of the leaf are mostly 30–36μ.

Habitat: On logs and soil in woods.
Distribution: Jamaica: add, Morce's Gap, Bengry 305 p.p. (IJ); e. slope of Mossman's Peak, M. Farr 727 (IJ); summit of High Peak, M. Farr 901, 911 p.p., 912, 921, 922 (IJ); summit of East Peak, Powell & Farr 1026, 1028, 1029, 1030, 1033, 1037 (IJ); summit of Sugar Loaf, M. Farr 1080, 1084, 1085, 1087, 1091, 1093 (IJ); without locality, Orcutt 2936, 2937, 2946, 2977, 5322, 5591 (BM); without locality, Hausen, as *M. portoricense* (G).—Santo Domingo (Dominican Republic).—Puerto Rico.—St. Kitts.—Guadeloupe: add, without locality, 760 m., Duss 211 (G).—Dominica: Roseau Valley, Elliott 31b (BM); Morne Micotrin, Elliott 26b p.p., 32a, 1129a p.p. (BM); summit of Caulisbon, Elliott 1872a, 1918b (BM); without locality, Elliott 1617 (G).—St. Vincent: (original, FH, G).—Trinidad.—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Mexico: Chiapas: Montebelo, Sharp 3577 (TENN); Michoacan: Cerro Grande, Frye & Frye 2782 (PH).—Guatemala: Pitoreal, Sharp 2772 (TENN).—Colombia: add, without locality, Irmscher 29, original of *M. colombicum* (G); without locality, Schlim, as *M. scutigerum* (G); Dept. Norte de Santander, Sarara, Cuatrecasas, Schultes & Smith 12448 cc, dd, E, L, N, O. (US).—Venezuela: Cura, Alston 6164 (BM); Cumbre, Cowan, & Wurdack 31326 (NY); without locality, Fendler 30 (G); Caracas: Merida, 4500', Funck & Schlim 350 bis, as *M. scutigerum* (G); Valencia, Fendler, as *M. scutigerum* (G).—British Guiana: Roraima, McConnell & Quelch 512 p.p., as *M. deciduum* f. *etiolata* (G)—Brazil: Caraça, Weinio, as *M. scutigerum* (G); S. Paulo: Campo Grande, Schiffner 458, 460, 461, 462, 463 p.p. 468, 469, 470, 479 (W); Basa Mansa, Schiffner 502, 1565, 1873 (W); Alto de Serra, Schiffner 1691 (W); Rio de Janeiro, Schiffner 2275 (W); Apiahy, Puiggari 108, 648, 759a, 764, 781a, 882, 1115, Y, as *M. scutigerum* (G); Parana, Dusén 3899, 3916 (G); Apiahy, Puiggari 276a, 782e, as *M. cuervi* (G); Rio de Janeiro, Glaziou 7227b, as *M. scutigerum* (G).—Ecuador.—Peru: Mt. Campana, Spruce (G).—Bolivia.

21a. BAZZANIA TRICRENATA (Wahlenb.) Trevis. Mem. Ist. Lomb. **13**: 414, 1877. [For synonomy and illustrations see Fulford, Amer. Midland Nat. **17**: 398. 1936.]

Plants in mats or scattered among mosses, filiform to medium size, olive green more or less pigmented with dark brown, sometimes reddish; stems slender, 2–8 cm long, with leaves to 2 mm broad, prostrate to ascending; flagelliform branches numerous: leaves distant to imbricated, tending to be falcate, curved around the stem when dry, persistent, ovate-triangular, to 1 mm long, to 0.6 mm broad at the base, narrowing to the acute or obliquely truncate two or three toothed apex; the teeth 2–6 cells long, 1 or 2 to 5 cells broad at the base; the cells thin-walled, the trigones small, distinct, the cuticle smooth to slightly verruculose; cells of the apical portion of the leaf 20–26μ long, mostly 22μ wide: underleaves distant to approximate, squarrose, broadly quadrate-orbicular, broader than the stem, to 0.35 mm long, to 0.45 mm wide, the apex usually undulate to four-lobed, the lateral margins undivided to occasionally irregularly lobed or toothed. Female branches and sporophytes not seen on the Central American material.

Habitat: On soil banks; also, on soil, logs, tree trunks and rocks in woods, in the Northern Hemisphere.

Distribution: Guatemala: Chimaltenango, on moist bank, cerro above Tecpán 9300', Sharp 2582 (TENN); in North America the species is known

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FIGS. 54–62. *B. crassidentata.* FIG. 54. Portion of a stem, ventral view, × 15. FIG. 55. Portion of a stem and leaf, dorsal view, × 15. FIG. 56. Apices of leaves, × 10. FIG. 57. A tooth of a leaf, × 360. FIG. 58. A cell from the apical portion of a leaf, × 360. FIG. 59. An underleaf, × 40. FIG. 60. Portion of a transverse section of a stem, × 360. FIG. 61. Female bracts, (a) outermost, (b) intermediate, (c) innermost series, × 40. FIG. 62. Portion of one of the laciniae of the perianth mouth, × 360. FIGS. 63–66. *B. chimborazensis.* FIG. 63. Portion of a plant, ventral view, × 15. FIG. 64. Apices of leaves, × 40. FIG. 65. A cell from the apical portion of a leaf, × 360. FIG. 66. Underleaves, the boundary of the hyaline area indicated by a dotted line, × 40. Figures 54–62 drawn from a portion of the type collected by Cowan & Wurdack in Venezuela (NY); figs. 63–66 from the original material collected by Spruce in Mt. Chimborazo, Ecuador, **Hepat. Spruc.** (G).

from northern California, Washington, Oregon, Idaho, British Columbia and southern Alaska and from eastern Canada south to North Carolina, and west to eastern Kentucky and Tennessee.

To my knowledge this collection by Dr. Sharp is the first record south of the U. S. for this species which is common and circumboreal in the Northern Hemisphere. So far as is known *B. tricrenata* is the only one of the North American species of *Bazzania* which occurs south of the U. S. None of the tropical American species has been found in the U. S.

Thus, *B. tricrenata* becomes another in the list of plants with a disjunct distribution which includes areas in eastern (and western) North America and the Highlands of Mexico-Guatemala.

22. BAZZANIA LATIDENS (G.) Fulford.
Habitat: Over rocks.
Distribution: Mexico: Cepecal, Karsten 9 (G.)—Brazil: (original, FH, G).

23. BAZZANIA LONGA (Nees) Trevis.
and B. longa var. papillata (Steph.) Fulford.

Plants of this highly variable species may be quite small, or medium size to very large. The leaves are more or less falcate and unequally three toothed, with the basiscopic tooth often reduced to a spine. Stems from a number of localities (especially from Dominica), have many leaves with only two teeth, and some of these stem suggest *B. roraima* of the Subgenus Bidentatae rather than *B. longa*. The underleaves may be small, rounded and distant, or longer and imbricated. In any case, the apical margin is entire and at most, only faintly undulate. Some small forms of this species are no doubt confused with *B. longistipula* and perhaps other species, in the distribution lists.

Habitat: On logs, rocks and over tree bases.
Distribution: Cuba: add, La Guinea, Wright (Hb Gottsche 8) (G).—Jamaica: add, summit of Sugar Loaf, M. Farr 1095 (IJ); without locality Orcutt 2821, 5352 (BM).—Puerto Rico.—St. Kitts.—Guadeloupe: add Soufrière, l'Herminier, as *M. subfalcatum* f. *minor* (G); without locality, Germain, as *B. longistipula* (G); without locality, l'Herminier 33/35, 64, 66, as *M. speciosum* f. *minor*, 68, 141 as *M. speciosum*, 77, 84 as *M. subfalcatum* (G.)—Dominica: add, Morne Micotrin, Elliott 92, 1091, 1098a, 1100a, 1106c p.p, 1155 p.p., 1228b, 1230d p.p. (BM); Roseau Valley, Elliott 13b (BM); Morne Trois Pitons, Elliott, 2242, 2250, 2254c, 2257a (BM) without locality as *M. cuervi* (G); without locality, Elliott 1155, as *M. portoricense*, 2242 (G); without locality, Elliott, as *M. scutigerum* (G); without locality, Elliott 1083, 1088, 1093, 1629, as *M. speciosum* (G).—Martinique: add, without locality, Bordaz 94 (G).—Trinidad: add, without locality, Beyrich (G).

23a. **Bazzania sublonga** Fulford, n. sp. Figures 42–46.
Caules mediocre vel grandes usque ad 6 cm longi, olivacei-virides vel fusculi, prostrati vel adscendentes; foliis imbricatis, falcatis, subquadratis, tridentatis, cellulis 27–36μ × 24–27μ: amphigastria quadrata vel rectandu-

laria, marginibus lateralibus rectis, apicalibus lobatis dentatisque cum dente incurvato uterque in terminis.

Plants medium size to large, in mats or tufts, olive green to brownish-green; stems 6 cm or more long, with leaves 3–4 mm broad, prostrate to ascending; lateral branches frequent, 1–2 cm apart, diverging at a wide angle; rhizoids scarce, from the scale-like leaves of the flagelliform branches: the line of leaf insertion curved in the upper half; leaves imbricated, falcate, becoming deflexed when dry, elongate, subrectangular to unsymmetrically ovate, 1.5–2.0 mm long × 0.5–0.8 mm broad at the base, little narrowed to the tridentate apex, the dorsal margin arched from the base which covers two-thirds of the stem, the ventral margin concave, the base scarcely dilated; the teeth equal to unequal, 3–6 cells broad at the base, 3–6 cells high, very sharp by one elongated cell, the sinuses rather broad, rounded, the margins straight to undulate, leaf cells elongate to angular-rounded in outline, the walls thin, the trigones very large, knot-like with convex sides, the cuticle faintly verruculose; cells of the apical portion 27–36μ × 24–27μ, those of the median and basal portions larger; underleaves attached in a straight line, imbricated, quadrate to rectangular in outline, 0.48–0.55 mm long and wide, the lateral margins straight or undulate, entire, the apex truncate, the apical margin with shallow lobes and teeth and usually an incurved tooth at each end; the cells as in the leaf; leaves of the flagelliform branches scale-like, ovate, mostly 0.25 mm in length: the female bracts (immature) crenate, laciniate. Male branches and perianth not seen.

Habitat: On logs at higher altitudes.

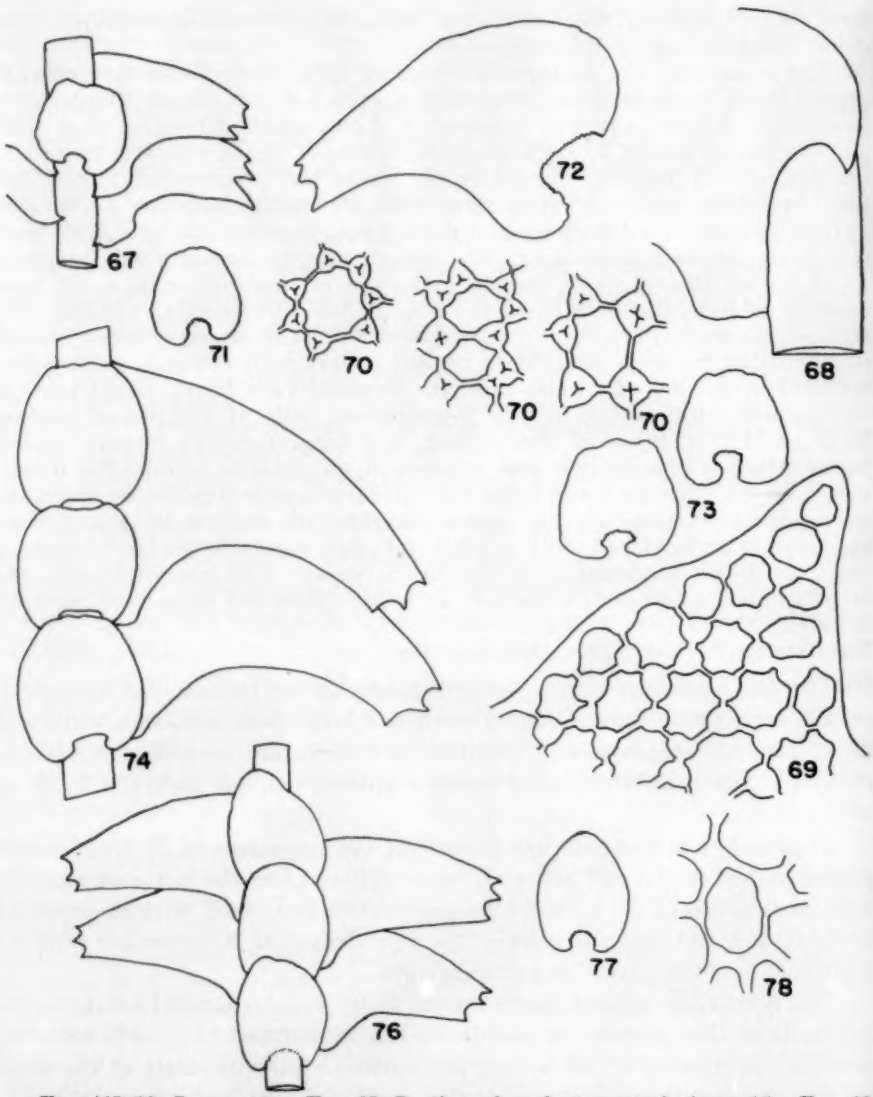
The distinguishing characters of this species are its size; the spreading, falcate leaves with sharp pointed teeth and large cells with thin walls and large, rounded trigones; and quadrate to rectangular underleaves with irregularly lobed and toothed truncated apices with an incurved tooth at each end.

This species is quite similar to some of the variations of *B. longa* in appearance, leaf shape and cell size, but it differs from the latter in that the truncated apices of the underleaves are toothed and lobed, with an incurved tooth at each end (Fig. 46), while the underleaves of *B. longa* are rounded or faintly undulate, with an entire margin.

The plants also suggest characters of *B. latidens* in general habit but the leaf cells of that species are mostly 20–24μ in contrast to 27–36μ × 24–27μ, and the underleaves of the former are entire or only undulate at the apex.

The shape of the underleaves is very similar to that in *B. glaziovii*, but in the latter species the leaf cells are only 20–24μ. *B. sublonga* is somewhat like some of the forms of *B. quadricrenata* in which the underleaves are not so deeply incised and lobed, but it can readily be distinguished from these forms, since the leaf cells of *B. quadricrenata* are mostly 22 × 22μ.

Distribution: Jamaica: summit of Cuna Cuna Mountain, M. Farr 1378, the type (IJ); the same, no. 1389 p.p. (IJ); summit of John Crow Peak, M. Farr 984 (IJ); sw. of Ecclesdown, M. Farr 1149 (IJ); Blue Mountain Peak, 6500–7325 ft., Underwood (cited as *B. latidens*) (NY).



FIGS. 67–78. *B. arcuata.* FIG. 67. Portion of a plant, ventral view, × 15. FIG. 68. Portion of a stem and leaf, to show leaf insertion, × 38. FIG. 69. A tooth of a leaf, × 350. FIG. 70. Cells from the apical portion of a leaf, × 350. FIG. 71. Underleaf, × 15. FIG. 72. A leaf, × 30. FIG. 73. Underleaves, × 15. FIG. 74. Portion of a plant, ventral view, × 30. FIG. 75. A cell, × 350. FIG. 76. A portion of a plant, ventral view, × 15. FIG. 77. Underleaf, × 15. FIG. 78. A cell from the apical portion of a leaf, × 350. FIGURES 67–71 drawn from a portion of the original material collected by Liebmann in Oaxaca, Mexico (G); figures 72–73 from the material of *M. stoloniferum* var. *cubense*, Wright, from Cuba (G); figures 74–75 drawn from the original of *M. martianum* Gottsche, collected by Martius in Brazil (G); figures 76–78 from a portion of the original material of *M. ecuadorense* collected by Allioni in Ecuador (G).

23b. **Bazzania elongata** Fulford, n. sp. Figures 47–53.

Caules robusti, 6–10 cm longi, prostrati vel adscendentes; foliis patentibus, falcatis, 1.5–2.5 mm longis, latis 0.6–0.8 mm, 3 vel 2 dentatum apicem, versus diminuendibus, dentibus grandibus, longis inaequalibus; folii cellulae 36–45 $\mu \times 27\mu$, trigonibus valde grandibus, parietibus crassis, cuticula crasse verruculosa: amphigastria rectangularia, bis longiora latis, profunde 4 lobatis: bracteae ♀ 2–3 laciniatis: perianthio 5 mm longo, apice crenato.

Plants large to robust, deep yellowish-brown to dark brown, in mats or tufts; stems stout, 6–10 cm or more in length, with leaves to 4 mm broad; lateral branches distant, diverging at a wide angle, flagelliform branches frequent; rhizoids not seen: the line of leaf insertion curved in the upper part; leaves imbricated, more or less spreading-falcate, deflexed and often connivent when dry, unsymmetrically ovate, elongate, 1.5–2.5 mm long, 0.6–0.8 mm broad at the base, narrowing conspicuously to the obliquely truncate, three- or two-toothed apex; the dorsal margin strongly arched from a rounded base, covering the stem and often extending beyond, the ventral margin concave, the base scarcely dilated, the teeth large, mostly long, unequal, the acroscopic tooth the longest, 2–7 cells broad at the base, 3–10 cells long, often with a uniseriate tip of 2–6 cells, the sinuses deep, narrow, acute, the margins straight or uneven; the cells of the apical part of the leaf 36–45$\mu \times 27\mu$, those of the median portion and the base larger, the walls thin, with very large rounded trigones and secondary thickenings in the pits, the cell cavities angular-rounded to stellate; the cuticle coarsely verruculose; underleaves attached in a straight line, imbricated, long-rectangular in outline, twice as long as broad, 1.0–1.5 mm long $\times$ 0.5 mm broad, the lateral margins entire, parallel, the apex truncate, mostly deeply four-lobed, sometimes one lobe longer and acuminate as in the tooth of the leaf, the cells as in the leaf: leaves of the flagelliform branches large, scale-like, ovate, mostly 0.3 mm or more long, spreading, the cells thick-walled: the female bracts and bracteoles similar, ovate, two to three divided to one-fourth or less, the segments short laciniate with the margins crenate to short ciliate: the perianth to 5 mm. long, the mouth crenate.

Habitat: On trunks of living trees in *Bonnetia* forest.

The distinguishing characters of this species are the yellow brown color, the falcate leaves with long sharp teeth, often with a 2–6-celled uniseriate tip, and the long rectangular, deeply four-lobed underleaves which are twice as long as broad.

The species may be distinguished from *B. crassidentata* which is of a similar color but slightly larger by the acute but never apiculate teeth of its leaves and the approximately quadrate underleaves. The deep brown pigmentation and the very long, four-lobed underleaves will separate *B. elongata* from *B. pallid-virens*, which is light greenish-yellow at the growing tips. The underleaves of the latter species are shorter and are variously incised and often in part hyaline, but they are never deeply four-lobed.

In general appearance *B. elongata* suggests a very strongly pigmented, robust form of *B. longa*. It differs from that species, however, in that most of the teeth of the leaves have longer uniseriate tips, the leaf cells are much larger, and the underleaves are as long or much longer and are deeply four-

lobed. The underleaves of *B. longa* are entire or faintly two to four undulate.

Distribution: Venezuela: Estado Bolivar, Chimanta Massif, 2000–2100 m, Steyermark 75787, the type (NY).

23c. **Bazzania crassidentata** Fulford, n. sp. Figures 54–62.

Caules robusti 5–10 cm longi, prostrati vel ascendentes; foliis patentibus 2.5 mm longis, 1 mm basi latis versus apicem tribentatem diminuendubus, dentibus grandibus, longis, angustis, acutis; folii cellulae 45 × 27 μ, trigonibus, triradiatus, parietibus crassis; amphigastria longiora quam lata, subquadrata, undulata, lobata: bractea ♀ cum 4 laciniis crenatis: perianthium longum apice longe laciniato; bracteae ♂ late ovatae.

Plants in mats or deep tufts, yellow brown to dark brown, becoming blackish; stems robust, 5–10 cm long and with leaves, to 5 mm or more broad, prostrate to ascending; stem cells in transverse section very thick walled: lateral branches 1 cm or more apart, diverging at a wide angle; flagelliform branches frequent: rhizoids not seen: leaf insertion curved in the upper part; the leaves approximate to imbricated, spreading, a little falcate, linear-lanceolate, to 2.5 mm long, to 1 mm broad at the base, tapering to 0.3–0.5 mm at the obliquely truncate, coarsely tridentate apex; the dorsal margin convex from a straight base, covering only half the stem, the ventral margin concave, the base not dilated; the apex three toothed, the teeth large, variable, mostly long, narrow, acute, to 10 cells long, 5 cells broad at the base, the basiscopic tooth much smaller, the sinuses usually deep and acute, the margins entire; leaf-cells thin-walled, the trigones very large, tri-radiate, the pits scarcely visible; the cell lumen stellate, often becoming rounded; cuticle faintly verruculose; cells of the teeth averaging 26 × 29 μ, of the lamina just below the teeth 45 × 27 μ, of the median portion 55 × 27 μ and of the base 63–36 μ: the underleaves approximate to imbricated, broader than the stem, attached in a straight line, subquadrate to oblong, the lateral margins convex from a cordate base, occasionally lobed, the apex undulate or slightly lobed and with an occasional tooth at one or both ends, the cells thick-walled as in the leaf, with the outer one or two rows smaller: leaves of the flagelliform branches ovate, large, scale-like, to 0.24 mm long: the female branches solitary to several on a stem; the outermost bracts broadly ovate, two–three toothed above; those of the intermediate and innermost series larger, broadly ovate, divided to one-third into four crenate lacineae; cells of the lacineae averaging 0.65 μ long: the perianth long, the mouth divided into numerous long lacineae: male branches short, catkin-like; male bracts broadly ovate, concave: sporophyte not seen. Habitat: On tree roots, tree trunks and soil, 200 m.

The distinguishing characteristics of this species are its robust habit and deep brown pigmentation; the long, linear-lanceolate, tridentate leaves with large, coarse teeth and large, very thick-walled leaf cells; and the subquadrate, cordate, more or less lobed underleaves.

The general habit and color of the plant suggest *B. bidens*, a species with large, coarse teeth and large, very thick-walled leaf cells; and the However, the abundance of three-toothed leaves and the very long leaf cells, to 45 μ in the upper part of the leaf, together with the very thick walls of the cells, will at once distinguish *B. crassidentata*.

This species also has something of the aspect of *B. pallidevirens*, the size, spreading leaves with sharp, long teeth, the shape of the underleaves, and the large leaf cells. The two may be distinguished in that *B. pallidevirens* is always green, at most faintly tinged with brown, the underleaves are hyaline in the upper part, at least at the tips of the stems, and although the leaf cells are large, they are somewhat smaller and the individual trigones are more distinct.

Distribution: Colombia: Dept. del Valle, Rio Calima, Cuatrecasas 21087b (US); Venezuela: Cumbre, along west rim, south from Camp Cano, Cowan & Wurdack 31324, the type (NY).

24. BAZZANIA JAMAICENSIS (L. & L.) Trevis.

The plants from Jamaica are very striking with their broad, reniform underleaves which are yellow-brown and much broader that the stem, with thick-walled cells on the margins. The leaf cells are mostly 18–22 μ. In South America some of the material of this species is like that in Jamaica, broad underleaves with yellow borders, but in other collections, the underleaves are not so reniform, rather, they are broadly ovate with a cordate base. Some of these forms have a yellow margin, others do not. They are more like *B. wrightii* in appearance except that the leaf cells are smaller, about 20 μ and there are no elongate cells in the upper part of the underleaves.

Habitat: On tree trunks.
Distribution: Jamaica: (original, NY, G); add, e. slope of Mossman's Peak, M. Farr 744 (IJ); summit of High Peak, M. Farr 910 (IJ); Cinchona, A. Barry 1454 (IJ); Blue Mountain Peak, Harris 11060 p.p. (BM).—Costa Rica: add, Segovia, 4000′, Oersted (G); without locality, Brade (G).—Venezuela: Valencia, Fendler (G).—Brazil: add, S. Paulo: Rio de Janeiro, Schiffner 815 p.p. (W); S. Paulo: n'r Apiahy, Schiffner 2328 (W); without locality, Jack, ex hb. Hampe, as *M. brasiliense* (G); S. Catharina; Morro da Bateia, Reitz 1.930, 1.931 (HBR); Minas Gerais, Caraça, Wainio 35, as *M. arcuatum* (G); Paraná, Dusén 3901 (G); S. Paulo, Delessert, as *B. glaziovii* (G).—Ecuador.—Peru.

25. BAZZANIA WRIGHTII (G.) Fulford.

The manuscript species, *M. stoloniferum* var. *cubense* Gottsche, *Hep. Cub. Wrightianae*, is more closely allied to *B. arcuata* discussed under No. 25a.

Habitat: On logs and tree bases.
Distribution: Cuba: (original, FH, YU, G).—Jamaica: add, Fairy Glade, M. Farr 771, 788 (IJ); Hardware Gap to waterfall, M. Farr 866, 867 (IJ); New Haven Gap, M. Farr 928 (IJ); Caledonia Peak, M. Farr 1007 (IJ); Hardware Gap, Baxter 11 (KANU).—Puerto Rico.—Guadeloupe: Galion, Le Gallo 266 (Le Gallo).—Dominica: Castle Bruce River, Elliott 11d (BM).

25a. BAZZANIA ARCUATA (Lindenb. & Gottsche) Trevis. Mem. Ist. Lomb. **13**: 414. 1877. Figures 67–78.
Mastigobryum arcuatum Lindenb. & Gottsche, in G. L. & N., Syn. Hep. p. 718. 1847.

Mastigobryum martianum Gottsche in Stephani, Hedw. **25**: 205. pl. 16. f. 9–12. 1886. *Non M. martianum* Lindb. syn. nov.
Mastigobryum stoloniferum var. *cubense* Gottsche ms. syn. nov.
Mastigobryum ecuadorense Stephani, Spec. Hepat. **6**: 461. 1924. syn. nov. [Stephani, Icones Hep., *Mastigobryum* nos. 159, 321a, 383, 393.]

Plants medium size to large, olive green, deeply pigmented with brown; stems to 5 cm or more in length, with leaves, 3–4 mm broad; lateral branches frequent, diverging at a wide angle, 5–10 mm apart; flagelliform branches numerous, long: rhizoids colorless, abundant on the scale-leaves of the flagelliform branches: the line of leaf insertion curved in the upper half, the dorsal end curved downward forming a very short hook: leaves imbricated, spreading and strongly arcuate or falcate from a broad base, sometimes becoming deflexed on drying, unsymmetrically ovate and narrowed to the tridentate apex, 2.0–2.5 mm long × 0.8–1.4 mm broad at the base and narrowed to 0.32–0.48 mm at the apex; the dorsal margin strongly arched from a cordate base, extending beyond the axis, the ventral margin strongly bowed from a conspicuous rectangular dilated ventral auricle; the apex usually irregularly toothed, the teeth acute, to 5 cells high, to 6 cells broad, the basiscopic tooth often much smaller, the sinuses mostly lunulate, the margins entire; leaf cells thin-walled, the trigones conspicuous, with bulging sides, the cell lumina angular-rounded, the cuticle slightly verruculose; cells of the apical region 20–26μ × 20–22μ, those of the median area larger, and those of the base 37–40μ, a vitta not differentiated: underleaves imbricated, subrectangular to oval, attached in a straight or slightly curved line, twice as broad as the stem, strongly cordate at the base, 0.6–1.4 mm long, 0.6–0.9 mm broad at the base, the lateral margins slightly convex, entire, the apical portion rounded-entire or more rarely straight, undulate or with a short tooth: leaves of the flagelliform branches scale-like appressed: the female branches solitary, the bracts and bracteoles similar, the outermost series short, bluntly ovate, the intermediate and innermost series longer, with three or four ciliate lacineae; the perianth long exserted, the mouth laciniate-ciliate; male branches short, catkin-like, the bracts broadly ovate, very concave: sporophyte not seen.
Habitat: On trees, moist cliff ledges and rocks in elevated regions.

The distinguishing characteristics of this species are its medium to large size, the strongly arcuate leaves with conspicuously dilated, rectangular ventral auricles, and the large, subquadrate to oval underleaves which are often broadest at the base.

Both *M. martianum* G. (figs. 74, 75) and *M. ecuadorense* Steph. (figs. 76–78) are conspecific with *Bazzania arcuata*. This species is quite similar in general aspect to *B. wrightii*. The two have many characters in common but *B. arcuata* differs from it in that the leaf has a more conspicuously hook-formed line of insertion, the ventral auricle is larger and the ventral margin of the leaf more deeply concave. In addition, the leaf cells tend to be slightly smaller, and the underleaves are more strongly cordate at the base and lack the numerous elongated cells with intermediate thickenings just below the apical margin, which are so conspicuously developed in *B.*

wrightii. The species is also similar in size and general aspect to forms of *B. breuteliana* but differ from it in that the leaves are very strongly arcuate and narrowed to the apex from a very broad base which has a large, conspicuously dilated ventral auricle, while in *B. breuteliana* the leaves are spreading or scarcely decurved, the apex is broad, the three teeth are usually broad, and the ventral auricle is not developed. The underleaves of the two species may be quite similar.

Distribution: Cuba: Domo del Gato, as *M. stoloniferum* var. *cubense* (G); the same, Wright (G).—Guadeloupe: Bory, Ed. Marie, cited by Bescherelle (1893, p. 9).—Martinique: Hahn, cited by Bescherelle (1893, p. 9). Mexico: Oaxaca: San Pedro Tepinapa, 2000–2500′, Liebmann, the original (G); Puebla, n'r Villa Juarez, Sharp 3150 (TENN).—Costa Rica: Prov. Cartago, Standley 50885, cited by Herzog (1938, p. 19); Mt. Hacum, Tonduz (G) without locality, Lehmann, cited by Stephani (1894, p. 402).—Colombia: Rio Apoporis, Schultes & Cabrera 11959 (FH).—Brazil: without locality, Martius, the original of *M. martianum* (G); Manáos, Ule 575, cited by Stephani (1905, p. 225); Apiahy, Puiggari 761a (G); S. Paulo: Alta da Serra, Schiffner 1610 (W); Rio Grande, Schiffner 1095 (W); n'r Barra Mansa, Itapecirca, Schiffner 1582 (W); Santos: St. Vincent, Horeau 10, as f. *robustior* (G); Santos, Mosén 99, as *M. vincentinum* (G) Ecuador: without locality, Allioni (Hb. Levier, 6406), original of *M. ecuadorense* (G); C. Bomboiza-Gualaquiza, Allioni 525, 724 (G).

References: Lindenberg & Gottsche (1851, 61. Pl. 22); Gottsche (1863, 128); Spruce (1890, 129; 1895, 356); Bescherelle (1893, 186); Stephani (1894, p. 402); 1895, 225; 1909, p. 527; Icones Hepaticarum, *Mastigobryum*, nos. 159, 371 a–d, 383, 393; Herzog (1938, p. 19).

(To be continued)

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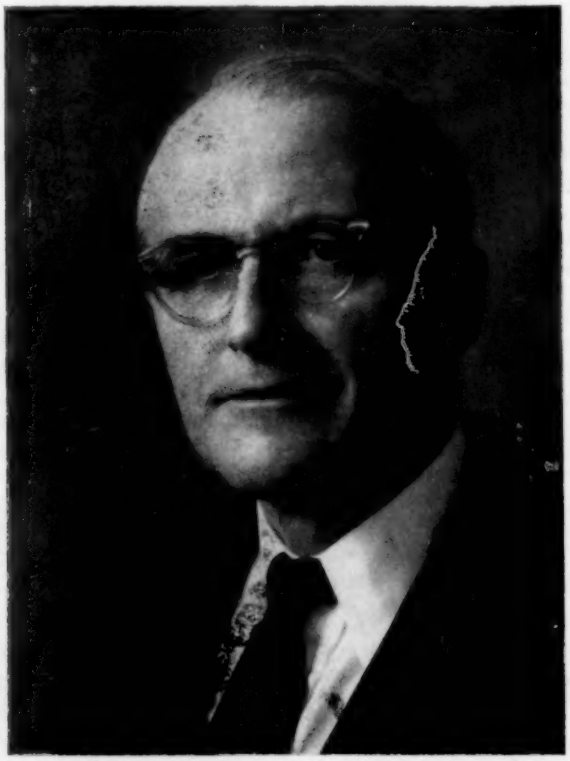
TORREYA

Albert Newton Steward

Helen M. Gilkey

Dr. Albert N. Steward, late Professor of Botany and Curator of the Herbarium at Oregon State College, was born near Fullerton, California, but in his later boyhood moved with his parents and family to Okanogan County, Washington. After graduation from high school in California, he entered Oregon State College in 1917, receiving a B.S. from that institution in 1921. In the meantime, the richness of the flora in his northeastern Washington home intrigued him, and he became interested in the taxonomy



Albert Newton Steward, July 23, 1897–June 19, 1959

of flowering plants. During his vacations he made collections for the O.S.C. herbarium, and eventually majored in botany. His senior year was spent, by special arrangement, as instructor in botany at the University of Montana.

While still a sophomore he married Celia B. Speak who, throughout the remainder of his life, collaborated closely with him in attaining his two major objectives, i.e., to contribute as widely as possible to his chosen professional field, and to become a useful world citizen. By the time of his graduation he had found the means by which these two objectives could be merged; and he and his wife were accepted by the Mission Board of the Methodist Church, for service in China.

From 1921 to 1926 he served as botanist at Nanking University. Returning, on leave, to the United States, he became assistant at Harvard where he remained until 1930, receiving from that institution, during those years, both M.S. and Ph.D. degrees, his taxonomic interest centering in the Polygoneae of Eastern Asia.

Returning to China in 1930, he became Professor of Botany at Nanking University, where he remained for twenty years, teaching, collecting plants and data, and developing means of counteracting the periodic ravages of famine, then so prevalent in Asia. During the later years of his stay, he underwent the trying periods of the second World War, Japanese occupation, and finally of Communist possession. Several times he had the opportunity to escape these by returning home on the Gripsholm. But, having already sent his family to America, he remained, believing that he could still be of service in China. At length, however, realizing that, under Communist rule, contacts of his Chinese friends with Americans endangered their lives, he applied for and eventually received permission to return to the United States in 1950.

That year, on a Guggenheim fellowship, he spent with the late Dr. Elmer Drew Merrill at the Arnold Arboretum, preparing the text for his Flora of the Lower Yangtze Valley. When he left China, all the collections and data for this flora, which he had been assembling for nearly thirty years, were confiscated by the Communists, and therefore lost to him. Fortunately, however, the duplicate collections which over the years he had been sending to America, particularly to Dr. Merrill, now served him in good stead, and the book eventually was published in 1958.

In 1951 Dr. Steward was appointed curator of the Oregon State College herbarium, which position he held until his death.

A glance at his bibliography will indicate his industry, broad interests, and the degree to which he concentrated on both the theoretical and practical phases of his profession. His devotion to botany in field, laboratory, classroom, herbarium, and office, was untiring. But even after his return to America, he made time and opportunity to devote himself likewise to his second objective as expressed in service to his church, the Oregon Trail Council of Boy Scouts, as chairman of the Oregon committee for the Fellowship of Reconciliation, of Oregon State College Round Table, and other far-reaching activities.

A fitting culmination of his professional life is his beautiful Flora of the Lower Yangtze Valley, whose preparation was shared by his wife. The book is dedicated to Dr. Merrill who collaborated with him during the many years of its development. Memorializing him, also, are the students of many races to whom he was friend and counselor, his colleagues who held him in high regard and respect, the teachers who still remember him as an eager young student, and all others so fortunate as to work with and know him. He bequeathes an honored name to his fine sons and daughters who already are establishing respected positions in their own right.

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TBC Report

JOSEPH MONACHINO

The Torrey Botanical Club is a non-profit organization devoted to presenting and discussing original work in botanical research, to disseminating knowledge in plant science, and to inspiring a profound appreciation of the beauty and importance of our great natural heritage throughout the world. It was started about 1866 and incorporated in 1873. It is named after the eminent John Torrey who, in 1817, published "A Catalogue of Plants Growing Spontaneously Within Thirty Miles of New York." In 1870 William Leggett founded the Bulletin of the Torrey Botanical Club, thus starting what is now the oldest botanical journal of this hemisphere. The Club was one of the agencies chiefly responsible for the organization of the New York Botanical Garden. Since its inception, it has been sponsored and inspired by some of the most distinguished botanists and naturalists of America. A leader in its early activity was Nathaniel Lord Britton, the first director of The New York Botanical Garden. He was a member of the Local Flora Committee, which then numbered E. P. Bicknell, K. K. Mackenzie and Norman Taylor, names illustrious in the annals of botany. Others working together with these, making vibrant the botanical atmosphere of the time, were W. A. Murrill, R. A. Harper, Percy Wilson, A. W. Evans, A. J. Grout; following them has been a host of other renowned botanists and naturalists, W. T. Davis, Witmer Stone, John Hendley Barnhart, James Edwards, H. K. Svenson, Rutherford Platt, H. N. Moldenke, etc. The New York Botanical Garden has always played one of the leading roles; within the last few years it has contributed from its top staff to the presidency or vice-presidency of the club, Donald P. Rogers, David D. Keck, Harold W. Rickett and the Director of the Garden, William C. Steere (Vice-President 1959). The total membership of the Torrey Botanical Club at present is about six hundred. Membership is unrestricted; it is open to anyone interested, amateur and professional alike. The following is an abbreviated report by Joseph Monachino, on the history of his acceptance of the position of Chairman of the Field Committee of the Torrey Botanical Club, his duties and what he hopes to accomplish in the field program.

Herewith is my report as Chairman of the Field Committee of the Torrey Botanical Club. I was appointed in 1957 and my duties are to organize the field program and prepare the field schedule.

I have participated in the field activities of the group for over twenty years. I first led a field trip for the Club in those ancient days when Raymond Torrey was Chairman of the Field Committee. In 1957 Dr. H. W. Rickett, President that year, approached me to accept the position of Field Chairman. I declined.

The field program of the Torrey Club was in danger of being discontinued, a possibility openly indicated (Bull. Torrey Club 83: 439–440. 1956)! The Club was inspired, I mused, on a field program, now running consecutively for the ninety-first season, and now this very field program might terminate! I recalled Torrey trips I had taken with Dr. William S. Thomas, author of the Field Book of Common Gilled Mushrooms; Norman

Taylor, author of the Flora of the Vicinity of New York; Guy Nearing, author of the Lichen Book; with William T. Davis to his famous grove of hybrid oaks in Staten Island; with A. T. Beales for the study of grasses; with Robert Hagelstein for the study of myxomycetes; with Edgar T. Wherry, George T. Hastings, Arthur H. Graves, E. J. Alexander, Alfred Gundersen, Leon Croizat, Henry K. Svenson, Harold N. Modenke, and so many others.

Dr. Rickett approached me again later, importuning the same question a second time, and then still a third time. I promised to discuss the matter with the then Head Curator and Assistant Director of The New York Botanical Garden, Dr. David D. Keck, as the position would entail Garden time and assistance.

Dr. Keck was enthusiastic about my accepting. He deemed it a heavy professional responsibility, good not only for botany and botanists in general, but also particularly for the New York Botanical Garden, as both an educational and research institution. Think it over, I demurred, for the position would mean my devoting to it plenty of Garden time and labor, extirpated from my routine duties, and also would require the unstinting help of the Garden secretary. This routine would be fully in the nature of a Garden assignment and a Garden responsibility, sometimes commanding priority attention over other work; it must not be regarded as a personal undertaking or as a secondary task for leisure time only. Dr. Keck agreed, alluding to the far-sighted vision of such a Garden venture, and still urged me to accept; but I suggested a period for deliberation before enlisting, and that I'd discuss the subject again in a week or so. In our second conference, Dr. Keck affirmed his previous sentiments.

Now, the job. It is chiefly two headed: 1) Get leaders for field trips; 2) Improve field attendance. A greatly increased effort must be made on both heads or the program will die. As mentioned before, the two are interrelated for if there is no leader there is no following, and without a fair attendance it is embarrassing, if not futile, to accost a leader. Also, generally, the better the leader the better the following, and vice-versa; but more than with numbers, I am concerned with quality. We wish our walks to be not only a healthy outdoor sport, but also highly instructive in natural sciences. To infuse ebullient youth into the Club and speed its pace is our great concern.

There is another requirement which in my mind is absolutely essential; it is that the program produce something permanent, specifically in the way of botanical publication. I do not believe anything has the right to exist just to amuse itself and least so the Torrey Botanical Club or any of its activities. The field program in this sense shall justify its existence.

Attempts to further foster the field program have been made by extending cooperation to other nature groups (e.g., the Palisade Nature Association in its Greenbrook Sanctuary botany study); personally participating in the field trips; suggesting interesting areas for exploration; initiating imaginative local flora study projects (Harry Lehr is tackling the genus *Carex* for the Torrey Range; Jimmy McGrath is backtracking old records of rare species); advertising by generous distribution of the field schedule booklet. You have seen Elizabeth C. Hall's inviting poster in the library of the New York Botanical Garden: "Do you like to hike? Are you a nature lover? etc."

To save printing expenses we condensed the type setting for the Field Schedule so that more information could be crammed into less space. The cover illustration is an attractive feature worth the time expended for its design and the cost for reproduction; that of 1958, Pillar Point, Greenbrook Sanctuary, was traced by Lucille Kopp, formerly artist at The New York Botanical Garden, from a photo in an exemplary book by Stephen Collins (1956) entitled "The Biotic Communities of Greenbrook Sanctuary"; 1959, Amphicarpun purshii in New Jersey was sketched in pencil by Joseph Monachino on bristol board furnished by Charles Clare, the Garden Artist, and was inked over by Frank C. MacKeever, Custodian of the Herbarium of the New York Botanical Garden.

Although we invite a measure of all nature studies in their broadest sense, ornithology, entomology (who is not aware of the profound effects of insects on flower evolution?), geology (some knowledge of glacial history and soil science is important in understanding plant distribution), microscopy, etc., our principal interest is botany in its many aspects. We hope to demonstrate by our field program and its results that

significant contributions can still be made in the botany of our local flora. This we have already partially done!

A field worker can pursue many phases of botany difficult or impossible for the herbarium man, such as phenology, insect visitors of flowers, mode of dissemination, habitat, variations, statistics, teratology, etc. The growth-habit and root-system of a plant, population analysis and ecology must be studied in the field.

There are examples in every imaginable category of valuable contributions that can be made by amateurs to our knowledge of the local flora. The living character of a plant and other distinctions so obvious in the field, like flower color, are often obscured or obliterated upon drying for the herbarium. For example, two species of *Geranium* found in the Bronx, *G. nepalense* and *G. sibiricum*, can be told apart yards away when growing, but pressed and dried they have been confused even by astute botanists. When I personally brought pressed specimens for inspection to a highly credited colleague, he queried "What *is* the difference?" There are differences between the two in almost every feature, including stem-rooting habit and flower color. Kodachrome slides, showing the color contrasts of these and other species, would be valuable accessories to the exsiccatae. There are numerous distinguishing characters not ordinarily recorded in botanical manuals, for instance those of seeds. In the springtime compare the flowers of oaks; in autumn study the internal morphology of winter-buds. Is it true that the petioles of *Polygonum cuspidatum* and *P. sachalinense* differ in the number of glands? Of the hundreds of *Ailanthus* samaras I have examined, the twist has always been dextrose; this might be verified by others. In frequent inspection of *Cerastium vulgatum*, the mouse-ear chickweed, I have found the petals usually cleft about one-third down to the yellowish-greenish base; but Fernald says "cleft to the middle". Is the average petal really split half-way when measured from top to bottom? If not, surely there might be greater precision regarding this common weed, too abundant as a pest in every lawn and garden! Greater precision in the true maxima, minima and average measurements is needed in numerous descriptions and this can be provided by conscientious amateurs who may know only a modicum of botany but can use a metric ruler accurately. Many observations are needed, for Nature is immensely prolific—she plays varieties on varieties! What is the full range of variation in the angle of divergence in the samara-wings of *Acer* species? (I have measured from horizontal to 70 degrees up in *A. platanoides*.) A careful observer, by repeated observations, might attempt to elucidate the *Bidens vulgata—comosa—connata—tripartita* complex; or make inquiry regarding the truly discrete elements comprising the *Eragrostis pilosa* complex, of which the species singled as *E. pectinacea* by Fernald is abundant underfoot in New York City. And as to the discovery of weeds new to the Torrey range or even to the western hemisphere (I have elsewhere furnished examples), the New Yorker will surely experience this sooner or later if he keeps his botanical eye open. How common is the white-rayed form of *Aster macrophyllus?* Is *Aristida oligantha* found in Connecticut? What is the distribution in the local area of *Potentilla anglica* and *Cynanchum medium?* Is there any other character but fruit color to distinguish *Pilea fontana* from *P. pumila?* Are there two American species or varieties of *Caulophyllum* instead of one? Are the bristles "clavate" on the stipe of the ovary in *Typha*, as described by Fernald? Is the European form of *Achillea millefolium* ("54 somatic chromosomes") found in the eastern United States? Are there two kinds of seeds in *Atriplex patula*, one of which is larger than the dimensions given in the manuals? Why is the fruit of *Cicuta maculata* figured in Gleason's Illustrated Flora cordate at the base? Can *Danthonia compressa* be told from *D. spicata* by the aristate teeth of its lemmas, as Gleanson indicates? Are the follicles "sessile" in *Eranthis hyemalis?* What is really the specific difference between *Polygonatum biflorum* and *P. canaliculatum?* Should *Sericocarpus* be merged with *Aster?* Should *Ampelopsis brevipedunculata* be considered a member of our spontaneous flora, and has *Lysimachia clethroides* escaped sufficiently to deserve treatment likewise? Are not the glumes of *Aristida purpurascens* about equal? Why is variety *drumondiana* of *Boehmeria cylindrica* called a *"sun form"*, when it appears to be a fairly good entity? Is not the style of *Clethra alnifolia* pilose at the base rather than "glabrous"? What are

good characters for distinguishing *Epilobium adenocaulon* from *E. coloratum*? I have seen only the variety *scabrella* of *Silene stellata* in the vicinity of New York; is var. *stellata* found in the Local Range? Is not *Symphytum asperum* occasionally found in our area?

In the Torrey field trip of August 3, 1958, we saw *Dianthus deltoides* near Litchfield, Conn.; the state is omitted in the range given by Gleason, although Taylor did cite northern Connecticut. Amateurs, by means of field work, can contribute to the accuracy of the distributional range of the local flora species. They can also aid in improving the description of the plant, too often drawn in the manuals from a very limited number of pieces of old dried specimens; aid by correcting errors, original, copied or accidental errors, all too rife in the published floras. Let one compare the leaves of *Desmodium nudiflorum* and *D. glutinosum*, picked in Van Cortlandt Park on a Torrey trip, with those figured in Gleason's Illustrated Flora. It will be instantly clear that the names were probably reversed in the Flora. Compare, compare with nature! The many instances of difference in concept between the two latest manuals, Fernald and Gleason, should be re-evaluated when possible. The numerous forms and minor varieties recognized by Fernald should not be categorically disregarded, but studied carefully, each on its own merit, with an eye for real distinction or real intergradation, studied in the open field when prolific examples are at hand, as they often are: there is a real difference between the forma *alba* which holds true against that which is merely an extreme of an impereceptibly intergrading color gradient. *Setaria faberii* was deliberately rejected by Gleason, but was afforded full species treatment by Fernald. It is prolific in the local area; see Dr. Fairbrother's valuable study of *S. faberii* New Jersey (Brittonia 11: 44–48, 1959). How good a species is this foxtail? The cycle of introduction, growth and disappearance of some weeds might be observed by one endowed with plenty of patience. *Inula graveolens*, for example, as seen in the Bronx, went through this cycle with amazing speed; it invaded a substantial area with great rapidity, forming a dense population (acting like the horseweed in vigor and habit), but within a short while disappeared completely. The diplomat who can find a financial sponsor will confer a decided service to the botanical novice by bringing Gleasons handbook, "Plants of the Vicinity of New York" (1935), up to date in its nomenclature, easily done by direct reference to Gleason's Illustrated Flora. Also, additional species now known for the Torrey range (e.g., *Polygonum cespitosum*) might be interpolated.

Observations made on field trips of the Torrey Botanical Club have already contributed to our knowledge of the local flora, as can be seen by my publications in Torreya. In 1958 alone I reported five Torrey trips, each of which added somewhat to our knowledge. In the report of the Jamaica Bay trip, led by E. J. Whelen on September 7, I mentioned the New York distribution of *Heterotheca subaxillaris* (not given for the state in the manuals), *Epilobium hirsutum* ("Que to Ill." in the Illus. Fl.), the viviparous habit of *Corynephorus canescens*, the species problem in *Froelichia*. In my account of the Van Courtlandt trip held on June 9, I reported *Epichloë typhina* (Identified by D. P. Rogers) and *Lepidium perfoliatum* from Woodlawn, a small flowered *Vicia tetrasperma*, a hairy-leaved *Agastache nepetoides*, 6-merous flowers in *Vitis labrusca*, the correct name for the figure *"Rhododendron serrulatum"* in Gleason's Illustrated Flora and the incorrect illustration of *Sanicula gregaria* in the same work, sepals of *Rhododendron viscosum* over 1 mm. long, the iodine colored juice in *Lysimachia quadrifolia* and instances of 4-merous flowers and 6 sepals in the species. The first trip I led for the Club was in 1938 at the site of the World's Fair Grounds in Queens, and even then I reported several weeds constituting first records.

Torrey leaders and members are encouraged to submit short reports of field activities for publication in Torreya. However, to warrant printing, the reports should contain original observations. It is not difficult to be original! Bare lists of species, as often submitted, unless intended towards a comprehensive floristic account, have little significance; even if lengthy they may add nothing in the way of extending records or knowledge of ecological interrelationships or other matters worthy of note. Be sparing of words and say only what has a quality of permanence.

What of the future? Shall I continue as chairman to build along the lines planned?

Foremost and essential in this consideration is the continued responsibility of the New York Botanical Garden, for which I am only an agent. I am encouraged by Torrey leaders and members who pledge cooperation. Dr. Fairbrothers, who introduced me to the chairmanship duties and laboriously helped in many ways, is joining the Field Committee. Dr. John A. Small, Editor of Torreya, is publishing our field reports and other local flora articles. Although all is not promising, the field program of the Torrey Botanical Club shows signs of resurgence!

FIELD TRIP REPORTS

March 22. St. John's in the Wilderness, Sloatsburg, N. Y. Weather: clear. Wind: northwest at 35 mph. Temperature: about 32°. Botany: a frigid group hiked for about an hour observing trees and shrubs in pre-spring growth before attending the annual service (see Torryea in Bull. Torrey Club **81**: 460, 1954, **82**: 397, 1955, **83**: 385, 1956, **84**: 318, 1957, **85**: 273, 1958). Attendance: Torrey 7, Rockland-Audubon 3. Leader, J. Harry Lehr.

April 12. Inwood Park, N. Y. The group was particularly interested in the hundreds of spicebushes in full bloom, Kenilworth-Ivy, Indian canes, and potholes. Wildflowers are not as numerous as they were several years ago, but seem to be gradually disappearing. Very few birds were seen. Attendance 11. Leader, Jane Meyer.

April 25. Huguenot, Staten Island, N. Y. A warm sunny day greeted the group. We walked along the shore of Arbutus Lake, which long ago received its name from the abundance of *Epigaea repens* on its shores. There were many patches of this beautiful flower in full bloom. This is the only area where this plant now occurs on Staten Island. Shadbush was also observed blooming nicely, as were trout lilies and spring beauties. A woodcock suddenly appeared in a grassy area. To the chatter of a small early flock of barn swallows the group ate lunch at the beach, returning along Arbutus Avenue and following it along to Amboy Road. Here there was a stand of escaped *Acanthopanax pentaphylla*. Apple, pear, cherry, flowering crab and Japanese quince were seen flowering along the way. We entered a woodland near Amboy Road and found a small stand of *Pyrola americana* with last year's fruiting stalks. Among these plants the *Pogonia verticillata* (*Isotria verticillata* in the recent edition of manuals) was just putting out its shoots, a little too early for flowering. After this climax of the day the group disbanded. Attendance 26. Leader, M. Weingartner.

May 24. East Woods, Van Courtandt Park, New York City. A pleasant Sunday afternoon brought 16 members to this area, which has, unfortunately, been cut up by new highways. The bristly locust, *Robinia hispida*, and *Acanthopanax pentaphyllum* were still flourishing, if not expanding, on the site of the old city nursery which had been abandoned about 20 years ago. The *Oxydendrum arboreum* which grew nearby, had disappeared. Leader, William Rissanen.

BOOK REVIEWS

Vascular Plants of the Pacific Northwest. Part 4: Ericaceae to Campanulaceae, inclusive. By C. Leo Hitchcock, Arthur Cronquist, Marion Ownbey, and J. W. Thompson. 510 pages. Completely illustrated. University of Washington Press, 1959. $12.00.

Part 4 was released by the press on April 16th, thus adding it to Part 5 which appeared in 1955. This evidence of progress in the preparation and publication of this important projected series of 5 volumes is of great satisfaction to all taxonomists of vascular plants, to horticulturalists, and to others who can use the information contained in such a work.

The Englerian sequence of families is followed, the present volume covering Ericaceae to Campanulaceae, inc. Naturally in such comprehensive coverage, a number of large—and, to many botanists, unwieldy and controversial—genera are found; but

that they are expertly handled is assured by the authoritative standing of the authors. It is axiomatic that in no treatment of such genera will the last or unchallenged word ever be said. But it is satisfying to have under one cover the combined opinions of specialists such as these.

An attractive and particularly helpful feature is the high standard maintained in the illustrations. The line drawings by Jeanne R. Janish are clear, graceful, and accurate, with welcome detailed enlargement of minute characters. The frequent notes on the horticultural value of given species will appeal to nurserymen, park officials, and any others interested in native ornamentals.

As in Part 5, genera and species are alphabetically arranged. This arrangement, the limited use of common names, and—in some cases—incomplete synonymy, are obviously compromises to accommodate the two types of persons to whom the publication is directed, i.e. (1) the layman, with informal taxonomic preparation; and (2) the technically trained taxonomist. But in these respects it is difficult to see how the gain to either counterbalances the loss to both.

In spite of these technicalities, however, the work as a whole will be of inestimable value to all who are concerned with vascular plants, and appearance of the remaining parts is eagerly awaited.—HELEN M. GILKEY.

Plants and Environment, A Textbook of Plant Autecology. By R. F. Daubenmire. xi + 422 pages. John Wiley & Sons. 1959.

The Second edition does not feature a great deal of revision. The ten chapter titles have remained the same as have most of the subject headings throughout the chapters. Many things however, have been added. An excellent figure on the relation of soil pH to nutrient availability is included in the second edition (Page 47). This figure enables the reader to see at a glance the general relationship between pH and nutrient availability. While the first edition only lists the 3 major horizons of the soil profile, the Second edition devotes Table 3 (Page 59) to these horizons and an explanation of their characteristics.

A new section deals with the increasingly important factor of atmospheric pollution (Page 251). The damage that has been caused by smelters in the past is explained along with a discussion of the effects of smog on plants. Attention is also called to the deleterious effects of smog on the human population. The examples above illustrate the types of revisions typical of the Second edition.

The illustrations have remained the same as those in the First edition. A section on frost-churning of soils has been added (Page 199) and 2 illustrations that show this phenomenon clearly have been included. The illustrations throughout the book are excellent and complement the text very well.

The bibliography has been expanded and now includes a total of 773 literature citations. Of these, approximately 200 are papers that have been published after 1947. This large and up-to-date bibliography will be a help to both the instructor and the student.

The overall effect of the revision has been to make this an even more valuable work in the field of ecology. The excellent organization of the material and the clear style of writing make this a text that is both factual and readable. If this book is not used as the main text in an ecology class, it should be present as a ready reference for the student.—JOHN M. BERNARD, Department of Botany, Rutgers, The State University of New Jersey, New Brunswick, New Jersey.

Systematics of Today. Proceedings of a Symposium Held at the Univ. of Uppsala in Commemoration of the 250th Anniversary of the Birth of Carolus Linnaeus. 29 authors and titles. Editor: Olov Hedberg. 243 pp. Uppsala Universitets Årsskrift 1958: 6. A.-B. Lundequistska Bokhandelin.

Zoological and botanical systematists from Europe and the United States were

invited to present papers in a commemorative symposium, May 28–29, 1957. The symposium is introduced by J. A. Nannfeldt's Presidential Address.

The major topics for discussion are problems and methods related to infraspecific taxa, but higher categories are discussed occasionally (Tuomikoski: Uber den heutigen Stand der Laubmoosesystematik; Pichi-Sermolli: The higher taxa of the Pteridophyta). The "species problem" and nomenclatorial aspects are omitted.

There are several good papers presented in the symposium. If these had been presented in some outlined order, there would have been less confusion as to the nature of the contents. From the title one might assume that the work could be used as a reference text for students. Obviously this was not the intent of the organizers of the symposium. I have not been able to find a pattern of order followed in the sequence of papers.

Various problems of the place and nature of ecotypes in taxonomic work are discussed. Genetic and geographic data for subspecific categories in certain taxa are presented. There is much worthwhile material in the text for the worker in taxonomy, but the book is not recommended for general reading.—DAVID J. ROGERS.

The Living Forest. By Jack McCormick. 127 pp., about half of them drawings or photographs. Harper & Brothers. 1959. $3.95.

This s a splendid little book if you want a gift to leave with a nature-loving hostess after an overnight visit. It reads rapidly, holds the interest, and demands a minimum of concentration. It will relax the reader, perhaps. I had a feeling that it is museumish so I went to the American Museum of Natural History to see the Hall of North American Forests that is mentioned at the start of the Preface. Several of the chapter titles are captions in the exhibits so the two go nicely together. You would also enjoy taking the book into a forest, alone, and reading it there.

But the title and dust cover led me to anticipate much more than was delivered. I wish this title had been reserved until McCormick had time to write much more expansively from his studies, travels, and actual living in the forests of North America.

In the first chapter the forest is treated as nature's city and the great numbers of life forms, animal and plant, are arranged in their places as manipulators of energy; food producers, primary consumers, secondary predators, and scavengers plus an incidental loss of energy by removal of materials from the forest city.

The second chapter, with no more than four full pages of type, is a surprisingly brief consideration of the forest floor, and the illustrations, occupying about equal space, are not inspiring. Rather than leaving to deduction, why not emphasize that here is the region where the greatest amount of energy exchange and transformation of substances occurs? Here is most of the life, birth, death, and decay; the greatest numbers and greatest variety of living things; the greatest cooperation, the most rugged competition, and the most merciless predation. And what about the physical environment? The tremendous importance of water in the organic and inorganic interaction; the seasonal change in moisture content, soil acidity, temperature, and impinging light; the contrast of dormant periods with those of extreme activity—all of this at one's feet in the living forest!

Eight types of forest insects are recognized in chapter 3. A more or less complete, but hardly detailed, life history of a selected species is given for each type with a page of descriptive matter and a facing page that is illustrative of one or more stages in the life cycle and something of the insect-host relationship. A tabulation of the common species of each type would seem useful here.

Chapter 4 treats of disease as an ecological factor within the forest. It is pointed out that disease or poor health ranges in cause from environmental insufficiency to parasitisim by another organism. A less than optimum environment, while non-infectious, may adversely influence a species or the entire forest over a large area, e.g., a drought, or hurricane. The more usual illness is associated with a living causal agent of which virus, fungus, and flowering plant organisms are discussed and illustrated. Usually a single disease is made sufficient for example.

The forest climate is next explained and it is no simple matter, because there are many climatic factors. They interact; each, and therefore the whole is modified at every level from canopy to the forest floor. The author might then have pointed out that a forest is the nicest place out of doors in most any climatic situation.

Have you ever poked around the stump of a tree? It can be fun. McCormick has poked around a lot of stumps, in a scientific way. And while there is no compromise with accuracy here, there is a welcomed mellowing—well almost. For instance, instead of "Facts a stump can reveal," the chapter is titled "Stories a stump can tell."

To cover the forests of North America—Alaska to Columbia to Labrador plus deserts and grasslands—in six printed pages and with an explanation of the ecological reason for each of the eight forest types is quite a feat in itself. Each is a living forest and as such has its hurried introduction and a few additional words but not enough description to establish the beginning of enduring personal friendship with each of the forests.

Alternating prosperity and adversity are common to living things. Such is life. In the chapter "How nature harvests the forest," McCormick is at his best and, though the story is condensed, there is not the sense of strangling. Here the forest lives, struggles, and fights back to reestablish itself victorious as it always does in nature.

In the final chapter it is made clear that the forest was here first. What is not stated but may be easily inferred is the wholly reasonable possibility that the living forest may also be here after "Man and the forest" have had their day together. Why not go on to say that it is a good day together and a prudent man will see to its continuance, though civilization is more sensitive and more vulnerable than the forest and man is more sensitive to radioactive fallout?—J. A. S.

Handbook of Basic Microtechnique. By Peter Gray. ix + 252 pages. Figs. 1–154. McGraw-Hill Book Company, N. Y. Second edition. 1958. $6.00.

The first edition of this book (Blakiston Co., 1952) preceded the author's "The Microtomists's Formulary and Guide" (Blakiston Co., 1954), reviewed in Bull. Torrey Club **81**: 514–517, 1954. The two books belong together in a college level course so that directions may be at hand but more information may also be readily available. This edition has been nearly doubled in pages (141 to 252) and the book is the better for it. The greatest expansion has been the 58 pages of Part One, The Microscope. This is a major contribution, beginning with principles and progressing through the description and use of freshman (no condenser), medical, and research microscope types. There is a chapter on photomicrography which begins with "The nature of the photographic process" and proceeds through types of photographic material, photomicrographic cameras of the commonly used forms, to "taking a photomicrograph." Gray has a knack of condensing material without stripping it bare, in fact many chapters lead up to a tabulation of steps in the process under consideration.

Chapter 4, beginning Part Two, The Preparation of Microscope Slides, is also new. It graphically outlines the "types of microscope slides," thus making a purposeful introduction to what follows. Chapters 5 and 6 have no material change from the first edition. The type is somewhat larger throughout the second edition. Headings in caps and the use of boldface type makes the book more easily useful where a quick look at a topic within the chapters is desired.

Chapter 7 is a vigorous rewrite job yielding a more meaningful introduction to staining. Delafield's hematoxylin has been added for sections and it replaces Carazzi's hematoxylin in the indirect staining of whole mounts. LaCour's acetoorcein is a newcomer associated with the squash technique. There is a different celestine blue B formula for nuclear staining. Mallory's methylene blue-azure II-phloxine is included as a means of showing bacteria in diseased tissue.

Chapter 12, Making Sections, has a half page devoted to "dehydrating and clearing plant tissues" in which the tertiary butyl alcohol method is outlined. The tables dealing with defects, their probable causes and possible remedies is a carry over that has proved extremely useful to students and time saving to instructors.

Part Three, Specific Examples of Slide Making, now has 18 examples in contrast with the former 15. Example 3 has helpful illustrations of embryo mounts and Delafield's hematoxylin formula has been substituted for that of Carazzi. Incidentally, this whole-mount of a chick embryo has been changed from the 48 hour to the 33 hour stage. Example 4 is helped by the addition of photomicrographs showing good and bad preparations. Example 6 is new—blood smears with Wright's stain. Smears are described earlier, in chapter 11, as in the first edition, but this example with photomicrographs is a real help. Photomicrographs have been added also to the example of staining a bacterial film. A second new example describes squash preparation of the salivary gland of Drosophila with LaCours acetic orcein. The final new example is a triple stain, but not *the* triple stain by Mallory (1938) for diplococci in the liver of the rabbit.

There is an eight-page index.—JOHN A. SMALL, Douglass College, Rutgers—The State University of New Jersey.

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(See also under Morphology: Fan)

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